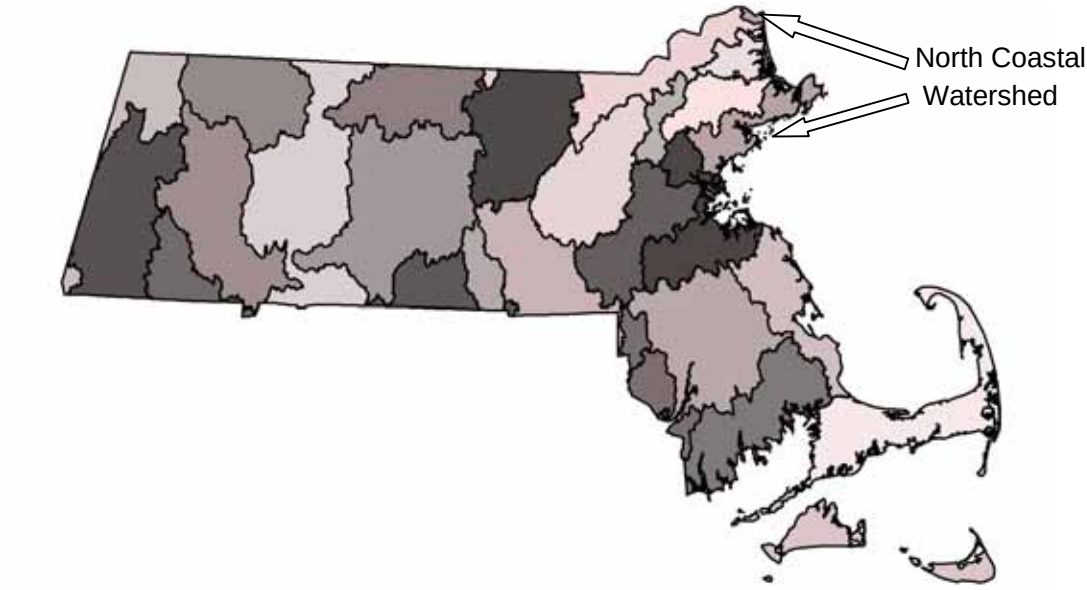
Draft Pathogen TMDL for the North Coastal Watershed



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NOTICE OF AVAILABILITY

Limited copies of this report are available at no cost by written request to:

Massachusetts Department of Environmental Protection (MADEP)
Division of Watershed Management
627 Main Street
Worcester, Massachusetts 01608

This report is also available from MADEP's home page on the World Wide Web.

A complete list of reports published since 1963 is updated annually and printed in July. This list, titled "Publications of the Massachusetts Division of Watershed Management (DWM) – Watershed Planning Program, 1963-(current year)", is also available by writing to the DWM in Worcester.

DISCLAIMER

References to trade names, commercial products, manufacturers, or distributors in this report constituted neither endorsement nor recommendations by the Division of Watershed Management for use.

Much of this document was prepared using text and general guidance from the previously approved Neponset River Basin and the Palmer River Basin Bacteria Total Maximum Daily Load documents.

Acknowledgement
This report was developed by ENSR through a partnership with Resource Triangle Institute (RTI) contracting with the United States Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Protection Agency under the National Watershed Protection Program.

Draft Total Maximum Daily Loads for Pathogens within the North Coastal Watershed

Key Features: Pathogen TMDL for the North Coastal Watershed
Location: EPA Region 1
Land Type: New England Coastal
303(d) Listings: Pathogens

Annisquam River (MA93-12);	Bass River (MA93-08);
Beaver Brook (MA93-37);	Beaverdam Brook (MA93-30);
Beverly Harbor (MA93-20);	Cat Brook (MA93-29);
Crane Brook (MA93-02),	Crane River (MA93-38, MA93-41);
Danvers River (MA93-09);	Essex Bay (MA93-16),
Essex River (MA93-11);	Forest River (MA93-10);
Frost Fish Brook (MA93-36);	Gloucester Harbor (MA93-18);
Goldthwait Brook (MA93-05);	Hawkes Brook (MA93-32, MA93-33);
Lynn Harbor (MA93-23);	Manchester Harbor (MA93-19);
Marblehead Harbor (MA93-22);	Mill River (MA93-28, MA93-31);
Nahant Bay (MA93-24);	North River (MA93-42);
Pines River (MA93-15);	Porter River (MA93-04);
Proctor Brook (MA93-39, MA93-40);	Rockport Harbor (MA93-17);
Salem Harbor (MA93-21);	Salem Sound (MA93-25);
Saugus River (MA93-14, MA93-34, MA93-35);	
Waters River (MA93-01)	

Data Sources:

- CZM 2004. Gloucester Harbor Characterization: Environmental History, Human Influences, and Status of Marine Resources.
- DMF 2002. The Marine Resources of Salem Sound, 1997.
- MADEP 2000. North Coastal Watershed 1997/1998 Water Quality Assessment Report.
- SRWC 2004. Saugus River Watershed 2003 Water Quality Report.
- SSCW 2004. Salem Sound Clean Beaches and Streams Program 2004 Report.

Data Mechanism: Massachusetts Surface Water Quality Standards for Fecal Coliform; The Federal BEACH Act; Massachusetts Department of Public Health Bathing Beaches; Massachusetts Division of Marine Fisheries Shellfish Sanitation and Management; Massachusetts Coastal Zone Management

Monitoring Plan: Massachusetts Watershed Five-Year Cycle

Control Measures: Watershed Management; Storm Water Management (e.g., illicit discharge removals, public education/behavior modification); CSO & SSO Abatement; Agricultural and other BMPs; No Discharge Areas; By-laws; Ordinances; Septic System Maintenance/Upgrades

Executive Summary

Purpose and Intended Audience

This document provides a framework to address bacterial and other fecal-related pollution in surface waters of Massachusetts. Fecal contamination of our surface waters is most often a direct result of the improper management of human wastes, excrement from barnyard animals, pet feces and agricultural applications of manure. It can also result from large congregations of birds such as geese and gulls. Illicit discharges of boat waste are of particular concern in coastal areas. Inappropriate disposal of human and animal wastes can degrade aquatic ecosystems and negatively affect public health. Fecal contamination can also result in closures of shellfish beds, beaches, swimming holes and drinking water supplies. The closure of such important public resources can erode quality of life and diminish property values.

Who should read this document?

The following groups and individuals can benefit from the information in this report:

a) towns and municipalities, especially Phase I and Phase II storm water communities, that are required by law to address storm water and/or combined sewage overflows (CSOs) and other sources of contamination (e.g., broken sewerage pipes and illicit connections) that contribute to a waterbody's failure to meet Massachusetts Water Quality Standards for pathogens;

b) watershed groups that wish to pursue funding to identify and/or mitigate sources of pathogens in their watersheds;

c) harbormasters, public health officials and/or municipalities that are responsible for monitoring, enforcing or otherwise mitigating fecal contamination that results in beach and/or shellfish closures or results in the failure of other surface waters to meet Massachusetts standards for pathogens;

d) citizens that wish to become more aware of pollution issues and may be interested in helping build local support for funding remediation measures.

TMDL Overview

The Massachusetts Department of Environmental Protection (MADEP) is responsible for monitoring the waters of the Commonwealth, identifying those waters that are impaired, and developing a plan to bring them back into compliance with the Massachusetts Water Quality Standards (WQS). The list of impaired waters, better known as the "303d list" identifies problem lakes, coastal waters and specific segments of rivers and streams and the reason for impairment.

Once a water body is identified as impaired, the MADEP is required by the Federal Clean Water Act (CWA) to develop a "pollution budget" designed to restore the health of the impaired body of water. The process of developing this budget, generally referred to as a Total Maximum Daily Load (TMDL), includes identifying the source(s) of the pollutant from direct discharges (point sources) and indirect discharges (non-point sources), determining the maximum amount of the pollutant that can be discharged to a specific water body to meet water quality standards, and assigning pollutant load allocations to the sources. A plan to implement the necessary pollutant reductions is essential to the ultimate achievement of meeting the water quality standards.

Pathogen TMDL: This report represents a TMDL for pathogen indicators (e.g. fecal coliform, *E. coli*, and enterococcus bacteria) in the North Coastal watershed. Certain bacteria, such as coliform, *E. coli*, and enterococcus bacteria, are indicators of contamination from sewage and/or the feces of warm-blooded wildlife (mammals and birds). Such contamination may pose a risk to human health. Therefore, in order to prevent further degradation in water quality and to ensure that waterbodies within the watershed meet state water quality standards, the TMDL establishes indicator bacteria limits and outlines corrective actions to achieve that goal.

Sources of indicator bacteria in the North Coastal watershed were found to be many and varied. Most of the bacteria sources are believed to be storm water related. Table ES-1 provides a general compilation of likely bacteria sources in the North Coastal watershed including failing septic systems, combined sewer overflows (CSO), sanitary sewer overflows (SSO), sewer pipes connected to storm drains, certain recreational activities, wildlife including birds along with domestic pets and animals and direct overland storm water runoff. Note that bacteria from wildlife would be considered a natural condition unless some form of human inducement, such as feeding, is causing congregation of wild birds or animals. A discussion of pathogen related control measures and best management practices are provided in the companion document: "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*".

This TMDL applies to the 36 pathogen impaired segments of the North Coastal watershed that are currently listed on the CWA § 303(d) list of impaired waters. MADEP recommends however, that the information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing "pollution prevention TMDLs" consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This North Coastal watershed TMDL may, in appropriate circumstances, also apply to segments that are listed for pathogen impairment in subsequent Massachusetts CWA § 303(d) Integrated List of Waters. For such segments, this TMDL may apply if, after listing the waters for pathogen impairment and taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

Since accurate estimates of existing sources are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For the illicit sources, the goal is complete elimination (100% reduction). However, overall wet weather indicator bacteria load reductions can be estimated using typical storm water bacteria concentrations. These data indicate that in general two to three orders of magnitude (i.e., greater than 90%) reductions in storm water fecal coliform loading will be necessary, especially in developed areas. This goal is expected to be accomplished through implementation of best management practices, such as those associated with the Phase II control program for storm water.

TMDL goals for each type of bacteria source are provided in Table ES-1. Municipalities are the primary responsible parties for eliminating many of these sources. TMDL implementation to achieve these goals should be an iterative process with selection and implementation of mitigation measures followed by monitoring to determine the extent of water quality improvement realized. Recommended TMDL implementation measures include identification and elimination of prohibited sources such as leaky or improperly connected sanitary sewer flows and best management practices to mitigate storm water runoff volume. Certain towns in the watershed are classified as Urban Areas by the United States Census Bureau and are subject to the Stormwater Phase II Final Rule that requires the development and implementation of an illicit discharge detection and elimination plan. Combined sewer overflows will be addressed through the on-going long-term control plans.

In most cases, authority to regulate non-point source pollution and thus successful implementation of this TMDL is limited to local government entities and will require cooperative support from local volunteers, watershed associations, and local officials in municipal government. Those activities can take the form of expanded education, obtaining and/or providing funding, and possibly local enforcement. In some cases, such as subsurface disposal of wastewater from homes, the Commonwealth provides the framework, but the administration occurs on the local level. Among federal and state funds to help implement this TMDL are, on a competitive basis, the Non-Point Source Control (CWA Section 319) Grants, Water Quality (CWA Section 604(b)) Grants, and the State Revolving (Loan) Fund Program (SRF). Most financial aid requires some local match as well. The programs mentioned are administered through the MADEP. Additional funding and resources available to assist local officials and community groups can be referenced within the Massachusetts Non-point Source Management Plan-Volume I Strategic Summary (2000) “Section VII Funding / Community Resources”. This document is available on the MADEP’s website at: www.state.ma.us/dep/brp/wm/wmpubs.htm, or by contacting the MADEP’s Nonpoint Source Program at (508) 792-7470 to request a copy.

Table ES-1. Sources and Expectations for Limiting Bacterial Contamination in the North Coastal Watershed

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
A, B, SA, SB	Illicit discharges to storm drains	0	N/A
A, B, SA, SB	Leaking sanitary sewer lines	0	N/A
A, B, SA, SB	Failing septic systems	N/A	0
A	NPDES – WWTP	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples nor shall 10%of the samples exceed 100 organisms[2]	N/A
A	Storm water runoff Phase I and II	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples nor shall 10%of the samples exceed 100 organisms[3]	N/A
A	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples nor shall 10%of the samples exceed 100 organisms[3]
B & Not Designated for Shellfishing SA & SB	CSOs	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[4]	N/A
B & Not Designated for Shellfishing SA & SB	NPDES – WWTP	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[2]	N/A
B & Not Designated for Shellfishing SA & SB	Storm water runoff Phase I and II	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[3]	N/A
B & Not Designated for Shellfishing SA & SB	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[3]

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
SA Designated Shellfishing Areas	NPDES – WWTP	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms[2]	N/A
SA Designated Shellfishing Areas	Storm water Runoff Phase I and II	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms[3]	N/A
SA Designated Shellfishing Areas	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms[3]
SB Designated Shellfishing Areas	CSOs	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[4]	N/A
SB Designated Shellfishing Areas	NPDES – WWTP	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[2]	N/A
SB Designated Shellfishing Areas	Storm water runoff Phase I and II	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[3]	N/A
SB Designated Shellfishing Areas	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[3]
No Discharge Areas	Vessels – raw or treated sanitary waste	0	N/A
Marine Beaches[5]	All Sources	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
Fresh Water Beaches[6]	All Sources	Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies OR *E. coli* not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies	Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies OR *E. coli* not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies

N/A means not applicable

[1] Waste Load Allocation (WLA) and Load Allocation (LA) refer to fecal coliform densities unless specified in table.

[2] Or shall be consistent with the Waste Water Treatment Plant (WWTP) National Pollutant Discharge Elimination System (NPDES) permit.

[3]The expectation for WLAs and LAs for storm water discharges is that they will be achieved through the implementation of BMPs and other controls.

[4] Or shall be consistent with an approved Long Term Control Plan (LTCP) for Combined Sewer Overflow (CSO) abatement. If the level of control specified in the LTCP is less than what is necessary to attain Class B water quality standards, then the above criteria apply unless MADEP has proposed and EPA has approved water quality standards revisions for the receiving water.

[5] Federal Beaches Environmental Assessment and Coastal Health Act of 2000 (BEACH Act) Water Quality Criteria

[6] Massachusetts Department of Public Health regulations (105 CMR Section 445)

Note: this table represents waste load and load reductions based on water quality standards current as of the publication date of these TMDLs, any future changes made to the Massachusetts water quality standards will become the governing water quality standards for these TMDLs.

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1.0 Introduction

Section 303(d) of the Federal Clean Water Act (CWA) and Environmental Protection Agencies (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to place waterbodies that do not meet established water quality standards on a list of impaired waterbodies (commonly referred to as the "303d List") and to develop Total Maximum Daily Loads (TMDLs) for listed waters and the pollutant(s) contributing to the impairment. In Massachusetts, impaired waterbodies are included in Category 5 of the "*Massachusetts Year 2002 Integrated List of Water: Part 2- Final Listing of Individual Categories of Waters*" (*2002 List*; MADEP 2003). Figure 1-1 provides a map of the North Coastal watershed with pathogen impaired segments indicated. Please note that not all segments have been assessed by the Massachusetts Department of Environmental Protection (MADEP) for pathogen impairment. As shown in Figure 1-1, portions of the North Coastal waterbodies are listed as a Category 5 "impaired or threatened for one or more uses and requiring a TMDL" due to excessive indicator bacteria concentrations.

TMDLs are to be developed for water bodies that are not meeting designated uses under technology-based controls only. TMDLs determine the amount of a pollutant that a waterbody can safely assimilate without violating water quality standards. The TMDL process establishes the maximum allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollutant sources and instream conditions. The TMDL process is designed to assist states and watershed stakeholders in the implementation of water quality-based controls specifically targeted to identified sources of pollution in order to restore and maintain the quality of their water resources (USEPA 1999). TMDLs allow watershed stewards to establish measurable water quality goals based on the difference between site-specific instream conditions and state water quality standards.

A major goal of this TMDL is to achieve meaningful environmental results with regard to the designated uses of the North Coastal waterbodies. These include water supply, shellfish harvesting, fishing, boating, and swimming. This TMDL establishes the necessary pollutant load to achieve designated uses and water quality standard and the companion document entitled; "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" provides guidance for the implementation of this TMDL.

Historically, water and sediment quality studies have focused on the control of point sources of pollutants (i.e., discharges from pipes and other structural conveyances) that discharge directly into well-defined hydrologic resources, such as lakes, ponds, or river segments. While this localized approach may be appropriate under certain situations, it typically fails to characterize the more subtle and chronic sources of pollutants that are widely scattered throughout a broad geographic region such as a watershed (e.g., roadway runoff, failing septic systems in high groundwater, areas of concentrated wildfowl use, fertilizers, pesticides, pet waste, and certain agricultural sources). These so called nonpoint sources of pollution often contribute significantly to the decline of water quality through their cumulative impacts. A watershed-level approach that uses the surface drainage area as the basic study unit enables managers to gain a more complete understanding of the potential pollutant sources impacting a waterbody and increases the precision of identifying local

Figure 1-1. North Coastal Watershed and Pathogen Impaired Segments.

problem areas or “hot spots” which may detrimentally affect water and sediment quality. It is within this watershed-level framework that the MADEP commissioned the development of watershed based TMDLs.

1.1. Pathogens and Indicator Bacteria

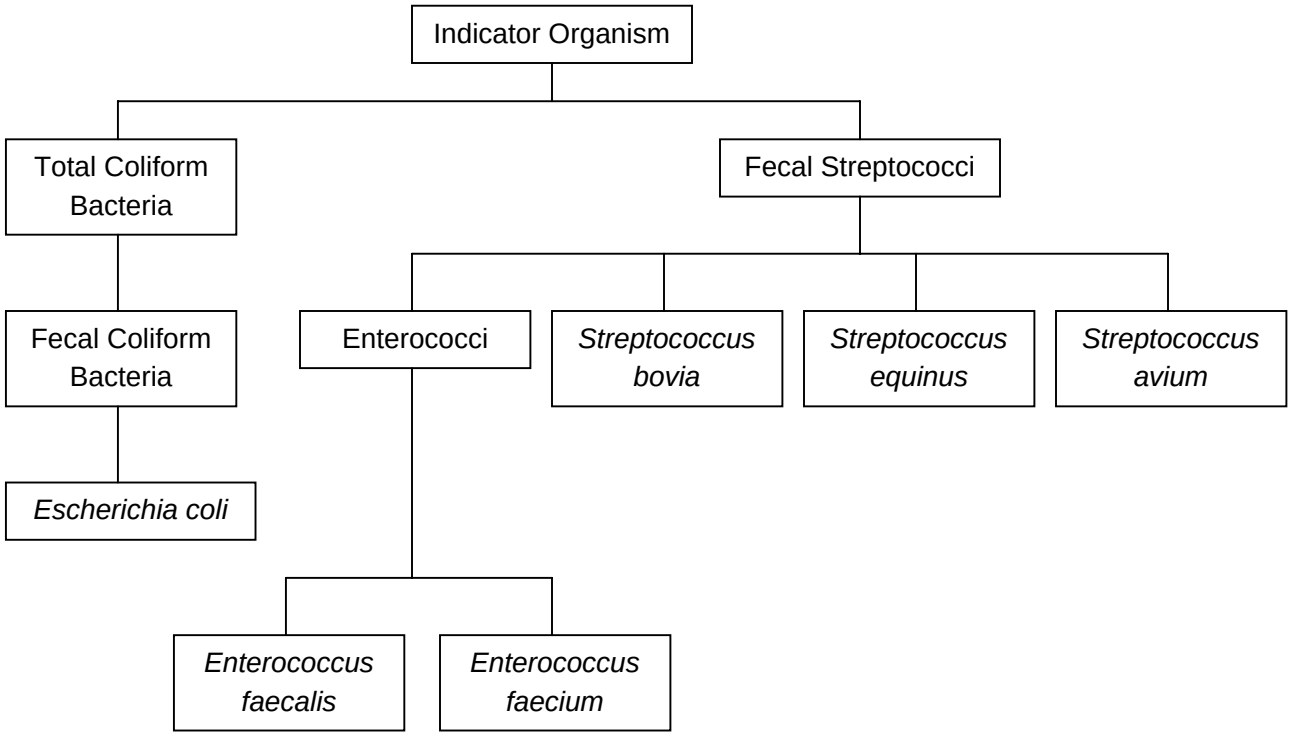
The North Coastal watershed pathogen TMDL is designed to support reduction of waterborne disease-causing organisms, known as pathogens, to reduce public health risk. Waterborne pathogens enter surface waters from a variety of sources including sewage and the feces of warm-blooded wildlife. These pathogens can pose a risk to human health due to gastrointestinal illness through exposure via ingestion and contact with recreational waters, ingestion of drinking water, and consumption of filter-feeding shellfish.

Waterborne pathogens include a broad range of bacteria and viruses that are difficult to identify and isolate. Thus, specific nonpathogenic bacteria have been identified that are typically associated with harmful pathogens in fecal contamination. These associated nonpathogenic bacteria are used as indicator bacteria as they are easier to identify and measure in the environment. High densities of indicator bacteria increase the likelihood of the presence of pathogenic organisms.

Selection of indicator bacteria is difficult as new technologies challenge current methods of detection and the strength of correlation of indicator bacteria and human illness. Currently, coliform and fecal streptococci bacteria are commonly used as indicators of potential pathogens (i.e., indicator bacteria). Coliform bacteria include total coliforms, fecal coliform and *Escherichia coli* (*E. coli*). Fecal coliform (a subset of total coliform) and *E. coli* (a subset of fecal coliform) bacteria are present in the intestinal tracts of warm blooded animals. Presence of coliform bacteria in water indicates fecal contamination and the possible presence of pathogens. Fecal streptococci bacteria are also used as indicator bacteria, specifically enterococci a subgroup of fecal streptococci. These bacteria also live in the intestinal tract of animals, but their presence is a better predictor of human gastrointestinal illness than fecal coliform since the die-off rate of enterococci is much lower (i.e., enterococci bacteria remain in the environment longer) (USEPA 2001). The relationship of indicator organisms is provided in Figure 1-2. The EPA, in the “*Ambient Water Quality Criteria for Bacteria – 1986*” document, recommends the use of *E. coli* or enterococci as potential pathogen indicators in fresh water and enterococci in marine waters (USEPA 1986).

Massachusetts uses fecal coliform and enterococci as indicator organisms of potential harmful pathogens. The WQS that apply to fresh water are currently based on fecal coliform concentration but will be replaced with *E. coli.* Fecal coliform are also used by the Massachusetts Division of Marine Fisheries (DMF) in their classification of shellfish growing areas. Fecal coliform as the indicator organism for shellfish growing area status is not expected to change at this time. Enterococci are used as the indicator organism for marine beaches, as required by the Beaches Environmental Assessment and Coastal Act of 2000 (BEACH Act), an amendment to the CWA.

Figure 1-2. Relationships among Indicator Organisms (USEPA 2001).



The North Coastal watershed pathogen TMDLs have been developed using fecal coliform as an indicator bacterium for fresh and marine waters and enterococci for marine beaches. Any changes in the Massachusetts pathogen water quality standard will apply to this TMDL at the time of the standard change. Massachusetts believes that the magnitude of indicator bacteria loading reductions outlined in this TMDL will be both necessary and sufficient to attain present WQS and any future modifications to the WQS for pathogens.

1.2. Comprehensive Watershed-based Approach to TMDL Development

Consistent with Section 303(d) of the CWA, the MADEP has chosen to complete pathogen TMDLs for all waterbodies in the North Coastal watershed at this time, regardless of current impairment status (i.e., for all waterbody categories in the *2002 List*). MADEP believes a comprehensive management approach carried out by all watershed communities is needed to address the ubiquitous nature of pathogen sources present in the North Coastal watershed. Watershed-wide implementation is needed to meet WQS and restore designated uses in impaired segments while providing protection of desirable water quality in waters that are not currently impaired or not assessed.

As discussed below, this TMDL applies to the 36 pathogen impaired segments of the North Coastal watershed that are currently listed on the CWA § 303(d) list of impaired waters and determined to be pathogen impaired in the "*North Coastal Watershed 1997/1998 Water Quality Assessment Report*" (MADEP WQA; MADEP 2000a) (see Figure 1-1, Table 4-3). MADEP recommends however, that the information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing "pollution prevention TMDLs" consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This North Coastal watershed TMDL may, in appropriate circumstances, also apply to segments that are listed for pathogen impairment in subsequent Massachusetts CWA § 303(d) Integrated List of Waters. For such segments, this TMDL may apply if, after listing the waters for pathogen impairment and taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

There are 79 waterbody segments assessed by the MADEP in the North Coastal watershed (MassGIS 2005). These segments consist of 23 estuaries, all of which are pathogen impaired. Thirteen of the 16 river segments are pathogen impaired and none of the 40 lake segments are pathogen impaired and appear as such on the official impaired waters list (303(d) List) (Figure 1-1). Pathogen impairment has been documented by the MADEP in previous reports, including the MADEP WQA, resulting in the impairment determination. In this TMDL document, an overview of pathogen impairment is provided to illustrate the nature and extent of the pathogen impairment problem. Additional data, not collected by the MADEP or used to determine impairment status, may also be provided in this TMDL to illustrate the pathogen problem. Since pathogen impairment has been previously established only a summary is provided herein.

The watershed based approach applied to complete the North Coastal watershed pathogen TMDL is straightforward. The approach is focused on identification of sources, source reduction, and implementation of appropriate management plans. Once identified, sources are required to meet applicable WQS for indicator bacteria or be eliminated. This approach does not include water quality analysis or other approaches designed to link ambient concentrations with source loadings. For pathogens and indicator bacteria, water quality analyses are generally resource intensive and provide results with large degrees of uncertainty. Rather, this approach focuses on sources and required load reductions, proceeding efficiently toward water quality restoration activities.

The implementation strategy for reducing indicator bacteria is an iterative process where data are gathered on an ongoing basis, sources are identified and eliminated if possible, and control

measures including Best Management Practices (BMPs) are implemented, assessed and modified as needed. Measures to abate probable sources of waterborne pathogens include everything from public education, to improved storm water management, to reducing the influence from inadequate and/or failing sanitary sewer infrastructure.

1.3. TMDL Report Format

This document contains the following sections:

- Watershed Description (Section 2) – provides watershed specific information
- Water Quality Standards (Section 3) – provides a summary of current Massachusetts WQS as they relate to indicator bacteria
- Problem Assessment (Section 4) – provides an overview of indicator bacteria measurements collected in the North Coastal watershed
- Identification of Sources (Section 5) – identifies and discusses potential sources of waterborne pathogens within the North Coastal watershed.
- TMDL Development (Section 6) – specifies required TMDL development components including:
    - Definitions and Equation
    - Loading Capacity
    - Load and Waste Load Allocations
    - Margin of Safety
    - Seasonal Variability
- Implementation Plan (Section 7) – describes specific implementation activities designed to remove pathogen impairment. This section and the companion "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" document should be used together to support implementing management actions.
- Monitoring Plan (Section 8) – describes recommended monitoring activities
- Reasonable Assurances (Section 9) – describes reasonable assurances the TMDL will be implemented
- Public Participation (Section 10) – describes the public participation process, and
- References (Section 11)

2.0 Watershed Description

The North Coastal watershed drains approximately 168 square miles of the Massachusetts' northshore (EOEA 2003). All or part of 26 Commonwealth communities, and a small portion of Seabrook New Hampshire, are within the North Coastal Drainage area[1]. It extends from Salisbury to the City of Revere including the following communities Amesbury, Everett, Malden, Melrose, Saugus, Stoneham, Reading, Wakefield, Lynnfield, Lynn, Nahant, Swampscott, Marblehead, Salem, Peabody, Danvers, Beverly, Manchester, Wenham, Hamilton, Essex, Ipswich, Gloucester, and Rockport (MADEP 2000a). This area supports a population of approximately 500,000 people (EOEA 2003).

The North Coastal watershed contains extensive areas of open space, rural towns, and highly urbanized communities (Table 2-1; Figure 2-1). "The topography of the watershed is characterized by small hills, which reach altitudes of about 350 feet above sea level, and low stream gradients…Within the NCW [North Coastal Watershed] boundaries there are a total of 85 lakes and ponds, 39 of which are greater than 10 acres" (EOEA 2004). "The total surface open of the North Coastal watershed lakes is 2,415 acres" (MADEP 2000a). "The rivers within the watershed are comparatively small, tidal and historically have been heavily exploited" (EOEA 2004). Barrier beach islands are a substantial portion of the coastal areas in the watershed. These barrier beaches include Salisbury Beach, Cranes Beach, Wingaersheek, and Revere Beach. Locations of public and semi-public beaches are illustrated on Figure 2-2. Detailed information regarding water quality at swimming beaches can be obtained from the beach quality annual reports available for download at the Massachusetts Department of Public Health website (http://www.mass.gov/dph/beha/tox/reports/beach/beaches.htm).

Surface waters in the watershed are commonly used for primary and secondary contact recreation (swimming and boating), viewing wildlife, habitat for aquatic life, lobster fishing, shellfishing, and potable water. There are no offshore areas protected against the disposal of treated or untreated sewage from vessels in this watershed (i.e., No Discharge Areas; see Section 7.7)(Figure 2-3).

[1] This document considers only those parts of the watershed that lie within Massachusetts.

Table 2-1. North Coastal Watershed Land Use as of 1999.

Land Use Category	% of Total Watershed Area
Pasture	0.7
Urban Open	2.0
Open Land	3.3
Cropland	1.0
Woody Perennial	2.1
Forest	31.3
Wetland/Salt Wetland	7.1
Water Based Recreation	0.7
Water	0.2
General Undeveloped Land	48.4
Spectator Recreation	<0.1
Participation Recreation	2.5
> 1/2 acre lots Residential	7.5
1/4 - 1/2 acre lots Residential	13.3
< 1/4 acre lots Residential	11.6
Multi-family Residential	1.9
Mining	0.4
Commercial	5.2
Industrial	3.9
Transportation	3.1
Waste Disposal	2.2
General Developed Land	51.6

Land use data are for the Massachusetts portion of the North Coastal watershed

Figure 2-1. North Coastal Watershed Land Use as of 1999.

Figure 2-2. North Coastal Watershed Marine Beach Locations and Pathogen Impaired Segments.

Figure 2-3. Massachusetts' No Discharge Areas (USEPA 2004a).

3.0 Water Quality Standards

The Surface Water Quality Standards (WQS) for the Commonwealth of Massachusetts establish chemical, physical, and biological standards for the restoration and maintenance of the most sensitive uses (MADEP 2000b). The WQS limit the discharge of pollutants to surface waters for the protection of existing uses and attainment of designated uses in downstream and adjacent segments.

Fecal coliform, enterococci, and *E. coli* bacteria are found in the intestinal tract of warm-blooded animals, soil, water, and certain food and wood processing wastes. "Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems" (USEPA 2004b). These bacteria are often used as indicator bacteria since it is expensive and sometimes difficult to test for the presence of individual pathogenic organisms.

Massachusetts is planning to revise its freshwater WQS by replacing fecal coliform with *E. coli* and enterococci as the regulated indicator bacteria, as recommended by the EPA in the "*Ambient Water Quality Criteria for Bacteria – 1986*" document (USEPA 1986). The state has already done so for public beaches through regulations of the Massachusetts Department of Public Health as discussed below. Currently, Massachusetts uses fecal coliform as the indicator organism for all waters except for marine bathing beaches, where the Federal BEACH Act requires the use of enterococci. Massachusetts anticipates adopting *E. coli* and enterococci for all fresh waters and enterococci for all marine waters, including non bathing marine beaches. Fecal coliform will remain the indicator organism for shellfishing areas, however. The North Coastal watershed pathogen TMDL has been developed using fecal coliform as the pathogen indicator for fresh and marine waters and enterococci for marine beaches, but the goal of removing pathogen impairment of this TMDL will remain applicable when Massachusetts adopts new indicator bacteria criteria into its WQS. Massachusetts believes that the magnitude of indicator bacteria loading reductions outlined in this TMDL will be both necessary and sufficient to attain present WQS and any future modifications to the WQS for pathogens.

Pathogens can significantly impact humans through ingestion of, and contact with recreational waters, ingestion of drinking water, and consumption of filter-feeding shellfish. In addition to contact recreation, excessive pathogen numbers impact potable water supplies. The amount of treatment (i.e., disinfection) required to produce potable water increases with increased pathogen contamination. Such treatment may cause the generation of disinfection by-products that are also harmful to humans. Further detail on pathogen impacts can be accessed at the following EPA websites:

- Water Quality Criteria: Microbial (Pathogen)
  http://www.epa.gov/ost/humanhealth/microbial/microbial.html
- Human Health Advisories:
  - Fish and Wildlife Consumption Advisories
    http://www.epa.gov/ebtpages/humaadvisofishandwildlifeconsumption.html

- Swimming Advisories
  http://www.epa.gov/ebtpages/humaadvisoswimmingadvisories.html

The North Coastal watershed contains waterbodies classified as Class A, Class B, Class SA, and Class SB. The corresponding WQS for each class are as follows:

> Class A waterbodies - fecal coliform bacteria shall not exceed an arithmetic mean of 20 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 100 organisms per 100 mL.
>
> Class B, and Class SA and SB not designated for shellfishing - the geometric mean of a representative set of fecal coliform samples shall not exceed 200 organisms per 100 mL and no more than 10% of the samples shall exceed 400 organisms per 100 mL. The MADEP may apply these standards on a seasonal basis for waters classified as Class B, and Class SA and SB not designated for shellfishing.
>
> Class SA waters approved for open shellfishing - the geometric mean of a representative set of fecal coliform samples shall not exceed 14 organisms per 100 mL and no more than 10% of the samples shall exceed 43 organisms per 100 mL.
>
> Class SB waters approved for open shellfishing - the geometric mean of a representative set of fecal coliform samples shall not exceed 88 organisms per 100 mL and no more than 10% of the samples shall exceed 260 organisms per 100 mL.

Shellfish growing areas are classified by the Massachusetts Division of Marine Fisheries (DMF). The classification system is provided below (MassGIS 2005). Figure 1-1 provides designated shellfish growing areas status as of July 1, 2000.

> **Approved** – “Open for harvest of shellfish for direct human consumption subject to local rules and state regulations.” (MassGIS 2005) “The area is shown to be free of bacterial contaminants under a variety of climatological and hydrographical situations (i.e. assumed adverse pollution conditions).” (MADEP 2002a)
>
> **Conditionally Approved** – "During the time area is approved it is open for harvest of shellfish for direct human consumption subject to local rules and state regulations.” (MassGIS 2005) “This classification category may be assigned for growing areas subject to intermittent and predictable microbiological contamination that may be present due to operation of a sewage treatment plant, rainfall, and/or season.” (MADEP 2002a)
>
> **Conditionally Restricted** – “During the time area is restricted it is only open for the harvest of shellfish with depuration subject to local rules and state regulations.” (MassGIS 2005) “A classification used to identify a growing area that meets the criteria for the restricted classification except under certain conditions described in a management plan.” (MADEP 2002a)

Restricted – "Open for harvest of shellfish with depuration subject to local rules and state regulations or for the relay of shellfish." (MassGIS 2005) "A classification used to identify where harvesting shall be by special license and the shellstock, following harvest, is subject to a suitable and effective treatment process through relaying or depuration. Restricted growing areas are mildly or moderately contaminated only with bacteria." (MADEP 2002a)

Management Closure – "Closed for the harvest of shellfish. Not enough testing has been done in the area to determine whether it is fit for shellfish harvest or not." (MADEP 2002a)

Prohibited – "Closed for harvest of shellfish." (MassGIS 2005) "A classification used to identify a growing area where the harvest of shellstock is not permitted. Growing area waters are so badly contaminated that no reasonable amount of treatment will make the shellfish safe for human consumption. Growing areas must also be classified as Prohibited if there is no or insufficient information available to make a classification decision." (MADEP 2002a)

In general, shellfish harvesting use is supported (i.e., non-impaired) when shellfish harvested from approved open shellfish areas are suitable for consumption without depuration and shellfish harvested from restricted shellfish areas are suitable for consumption with depuration. For an expanded discussion on the relationship between the DMF shellfish growing areas classification and the MADEP designated use support status, please see the "*North Coastal Watershed 1997/1998 Water Quality Assessment Report*" (MADEP WQA; MADEP 2000a).

In addition to the WQS, the Commonwealth of Massachusetts Department of Public Health (MADPH) has established minimum standards for bathing beaches (105 CMR 445.000) under the State Sanitary Code, Chapter VII (www.mass.gov/dph/dcs/bb4_01.pdf). These standards will soon be adopted by the MADEP as state surface WQS for fresh water and these standards will subsequently apply to this TMDL. The MADPH bathing beach standards are generally the same as those which were recommended in the "*Ambient Water Quality Criteria for Bacteria – 1986"* document published by the EPA (USEPA 1986). In the above referenced document, the EPA recommended the use of enterococci as the indicator bacterium for marine recreational waters and enterococci or *E. coli* for fresh waters. As such, the following MADPH standards have been established for bathing beaches in Massachusetts:

Marine Waters - (1) No single enterococci sample shall exceed 104 colonies per 100 mL and the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 35 colonies per 100 mL.

Freshwaters - (1) No single *E. coli* sample shall exceed 235 colonies per 100 mL and the geometric mean of the most recent five *E. coli* samples within the same bathing season shall not exceed 126 colonies per 100 mL; or (2) No single enterococci sample shall exceed 61 colonies per 100 mL and the geometric mean of the most recent five enterococci samples within the same bathing season shall not exceed 33 colonies per 100 mL.

The Federal BEACH Act of 2000 established a Federal standard for marine beaches. These standards are essentially the same as the MADPH marine beach standard (i.e., single sample not to exceed 104 cfu/100mL and geometric mean of a statistically sufficient number of samples not to exceed 35 cfu/100mL). The Federal BEACH Act and MADPH standards can be accessed on the worldwide web at http://www.epa.gov/waterscience/beaches/act.html and www.mass.gov/dph/dcs/bb4_01.pdf, respectively.

Figure 2-2 provides the location of marine bathing beaches, where the MADPH Marine Waters and the Federal BEACH Act standards would apply. A map of freshwater beaches is not available at this time. However, a list of beaches (fresh and marine) by community with indicator bacteria data can be found in the annual reports on the testing of public and semi-public beaches provided by the MADPH. These reports are available for download from the MADPH website located at http://www.mass.gov/dph/beha/tox/reports/beach/beaches.htm.

4.0 Problem Assessment

Pathogen impairment has been documented at numerous locations throughout the North Coastal watershed, as shown in Figure 1-1. Excessive concentrations of indicator bacteria (e.g., fecal coliform, enterococci, *E. coli* etc.) can indicate the presence of sewage contamination and possible presence of pathogenic organisms. The amount of indicator bacteria and potential pathogens entering waterbodies is dependent on several factors including watershed characteristics and meteorological conditions. Indicator bacteria levels generally increase with increasing development activities, including increased impervious cover, illicit sewer connections, and failed septic systems.

Indicator bacteria levels also tend to increase with wet weather conditions as storm sewer systems overflow and/or storm water runoff carries fecal matter that has accumulated to the river via overland flow and storm water conduits. In some cases, dry weather bacteria concentrations can be higher when there is a constant source that becomes diluted during periods of precipitation, such as with illicit connections. The magnitude of these relationships is variable, however, and can be substantially different temporally and spatially throughout the United States or within each watershed.

Tables 4-1 and 4-2 provide ranges of fecal coliform concentrations in storm water associated with various land use types. Pristine areas are observed to have low indicator bacteria levels and residential areas are observed to have elevated indicator bacteria levels. Development activity generally leads to decreased water quality (e.g., pathogen impairment) in a watershed. Development-related watershed modification includes increased impervious surface area which can (USEPA 1997):

- Increase flow volume,
- Increase peak flow,
- Increase peak flow duration,
- Increase stream temperature,
- Decrease base flow, and
- Change sediment loading rates

Many of the impacts associated with increased impervious surface area also result in changes in pathogen loading (e.g., increased sediment loading can result in increased pathogen loading). In addition to increased impervious surface impacts, increased human and pet densities in developed areas increase potential fecal contamination. Furthermore, storm water drainage systems and associated storm water culverts and outfall pipes often result in the channelization of streams which leads to less attenuation of pathogen pollution.

Table 4-1 Wachusett Reservoir Storm Water Sampling (as reported in MADEP 2002b) original data provided in MDC Wachusett Storm Water Study (June 1997).

Land Use Category	Fecal Coliform Bacteria[1] Organisms / 100 mL
Agriculture, Storm 1	110 – 21,200
Agriculture, Storm 2	200 – 56,400
"Pristine" (not developed, forest), Storm 1	0 – 51
"Pristine" (not developed, forest), Storm 2	8 – 766
High Density Residential (not sewered, on septic systems), Storm 1	30 – 29,600
High Density Residential (not sewered, on septic systems), Storm 2	430 – 122,000

[1] Grab samples collected for four storms between September 15, 1999 and June 7, 2000

Table 4-2. Lower Charles River Basin Storm Water Event Mean Bacteria Concentrations (data summarized from USGS 2002)[1].

Land Use Category	Fecal Coliform (CFU/100 mL)	Enterococcus Bacteria (CFU/100 mL)	Number of Events
Single Family Residential	2,800 – 94,000	5,500 – 87,000	8
Multifamily Residential	2,200 – 31,000	3,200 – 49,000	8
Commercial	680 – 28,000	2,100 – 35,000	8

[1] An Event Mean Concentration (EMC) is the concentration of a flow proportioned sample throughout a storm event. These samples are commonly collected using an automated sampler which can proportion sample aliquots based on flow.

Pathogen impaired estuary segments represent 100% of the total estuary area assessed (34.1 square miles). Pathogen impaired river segments represent 87.7% of the total river miles assessed (32.7 miles of 37.3 total river miles). In total, 36 segments, each in need of a TMDL, contain indicator bacteria concentrations in excess of the Massachusetts WQS for Class A, SA, B, or SB waterbodies (314 CMR 4.05)[1], the MADPH standard for bathing beaches[2], and/or the BEACH Act[3]. The basis for impairment listings is provided in the *2002 List* (MADEP 2003a). Data presented in the WQA and other data collected by the MADEP were used to generate the *2002 List*. For more information regarding the basis for listing particular segments for pathogen impairment, please see the Assessment Methodology section of the MADEP WQA for this watershed.

A list of pathogen impaired segments requiring TMDLs is provided in Table 4-3. "The North Coastal watershed consists of several small rivers that drain directly into the ocean rather than the more common watershed definition surrounding one large river." (EOEA 2004) For this reason it is more accurate to discuss the character and problems on a sub-watershed level. In this report, the North Coastal watershed will be divided as in the WQA into the following sub-watersheds:

- The Essex Bay System
- The Annisquam River System
- Rockport Harbor
- Gloucester Harbor
- Salem Sound System
- Manchester Harbor System
- Beverly Harbor System
- Salem Harbor
- Marblehead Harbor
- Nahant Bay
- Saugus River System

Additional details regarding each impaired segment including water withdrawals, discharges, use assessments and recommendations to meet use criteria are provided in the MADEP WQA.

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[1] Class A: Fecal coliform bacteria shall not exceed an arithmetic mean of 20 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 100 organisms per 100 mL.
Class SA (Shellfishing approved): Fecal coliform bacteria shall not exceed an arithmetic mean of 14 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 43 organisms per 100 mL.
Class SB (Shellfishing approved): Fecal coliform bacteria shall not exceed an arithmetic mean of 88 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 260 organisms per 100 mL.
Class B, Class SA & Class SB (waters not designated for shellfishing): Fecal coliform bacteria shall not exceed a geometric mean of 200 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 400 organisms per 100 mL. The MADEP may apply these standards on a seasonal basis.

[2] Freshwater bathing beaches: No single *E. coli* sample shall exceed 235 colonies per 100 mL and the geometric mean of the most recent five *E. coli* samples within the same bathing season shall not exceed 126 colonies per 100 mL; or No single enterococci sample shall exceed 61 colonies per 100 mL and the geometric mean of the most recent five (5) enterococci samples within the same bathing season shall not exceed 33 colonies per 100 mL.
Marine bathing beaches: No single enterococci sample shall exceed 104 colonies per 100 mL and the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 35 colonies per 100 mL.

[3] BEACH Act - Marine bathing beaches: No single enterococci sample shall exceed 104 colonies per 100 mL and the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 35 colonies per 100 mL.

Table 4-3. North Coastal Watershed Pathogen Impaired Segments Requiring TMDLs(adapted from MADEP 2000a and MassGIS 2005).

Segment ID	Segment Name	Segment Type	Size[1]	Segment Description
Essex Bay System				
MA93-11	Essex River	Estuary	0.9	Source east of Southern Avenue to mouth at Essex Bay, Essex.
MA93-16	Essex Bay	Estuary	1.15	Essex/Ipswich/Gloucester
Annisquam River System				
MA93-28	Mill River	Estuary	0.09	Outlet Mill Pond, Gloucester to confluence with Annisquam River, Gloucester.
MA93-12	Annisquam River	Estuary	1.9	Gloucester Harbor to Ipswich Bay, Gloucester.
MA93-17	Rockport Harbor	Estuary	0.02	Rockport
MA93-18	Gloucester Harbor	Estuary	2.24	Gloucester
Salem Sound				
MA93-29	Cat Brook	River	2.5	Headwaters north of Route 128 Manchester/Essex/Gloucester to confluence Manchester Harbor, Manchester. Miles 2.5-0.0
MA93-19	Manchester Harbor	Estuary	0.29	Manchester
MA93-08	Bass River	Estuary	0.1	Outlet of Shoe Pond north of Route 62 to confluence with Danvers River, Beverley.
MA93-36	Frost Fish Brook	River	1.3	Headwaters, southeast of Danvers locality of Putnamville to confluence Porter River just south of Route 62, Danvers. Miles 1.3-0.0
MA93-04	Porter River	Estuary	0.1	Confluence with Frost Fish Brook to confluence with Danvers River, Danvers.
MA93-37	Beaver Brook	River	3.5	Headwaters at wetland west of Dayton Street in Danvers to confluence with Crane River at Mill Pond in Danvers.
MA93-02	Crane Brook	River	2.3	Headwaters west of Newburyport Turnpike (Route 95) to inlet Mill Pond, Danvers.
MA93-38	Crane River	River	0.3	Outlet Mill Pond, Danvers to outlet of pump house sluiceway at Purchase Street, Danvers.
MA93-41	Crane River	Estuary	0.08	Outlet pump house sluiceway at Purchase Street, Danvers to confluence Danvers River, Danvers.
MA93-01	Waters River	Estuary	0.08	Headwaters north of Route 114, Peabody, to confluence with Danvers River, Danvers.
MA93-05	Goldthwait Brook	River	3.3	Outlet Cedar Pond to confluence with Proctor Brook, Peabody.
MA93-39	Proctor Brook	River	2.9	Outlet of small pond in wetland north of Downing Road, Peabody to Goodhue Street bridge, Salem.
MA93-40	Proctor Brook	Estuary	0.01	Goodhue Street bridge, Salem to Route 114 culvert, Salem.
MA93-42	North River	Estuary	0.2	Downstream of Route 114 bridge (Proctor Brook becomes North River at this bridge), Peabody to confluence with Danvers River, Salem.

Table 4-3 (continued). North Coastal Watershed Pathogen Impaired Segments Requiring TMDLs(adapted from MADEP 2000a and MassGIS 2005).

Segment ID	Segment Name	Segment Type	Size[1]	Segment Description
MA93-09	Danvers River	Estuary	0.5	Confluence with Porter, Crane and Waters rivers, Danvers to mouth at Beverly Harbor, Beverly/Salem.
MA93-20	Beverly Harbor	Estuary	0.78	East of Route 1A between Beverly/Salem to an imaginary line between Woodbury Point in Beverly southwest to Salem Neck in Salem
MA93-10	Forest River	Estuary	0.05	Approximately 1/2 mile upstream of Loring Avenue, Salem to mouth at Salem Harbor, Salem/Marblehead.
MA93-21	Salem Harbor	Estuary	1.62	Marblehead/Salem
MA93-22	Marblehead Harbor	Estuary	0.56	Marblehead
MA93-25	Salem Sound	Estuary	10.01	Beverly/Manchester
MA93-24	Nahant Bay	Estuary	5.27	Swampscott, Lynn, and Nahant
Saugus River Subwatershed				
MA93-34	Saugus River	River	3.1	Source, outlet of Lake Quannapowitt, Wakefield to canal which discharges to Hawkes Pond, Wakefield/Lynnfield.
MA93-30	Beaverdam Brook	River	2.5	Headwaters west of Main Street, Lynnfield to confluence with Saugus River, Lynnfield.
MA93-35	Saugus River	River	5.3	Canal which discharges into Hawkes Pond, Wakefield/Lynnfield to Saugus Iron Works, Saugus.
MA93-31	Mill River	River	2	From headwaters in wetlands north of Salem Street in Wakefield to confluence with Saugus River, Wakefield.
MA93-32	Hawkes Brook	River	2.6	Headwaters at the Lynn/Lynnfield border to the outlet of Hawkes Pond in North Saugus.
MA93-33	Hawkes Brook	River	1.1	Outlet of Hawkes Pond, North Saugus to confluence with Saugus River, Saugus.
MA93-14	Saugus River	Estuary	0.8	Saugus Iron Works, Saugus, to the mouth at Lynn Harbor, Lynn/Salem.
MA93-15	Pines River	Estuary	0.7	Route 1, Revere/Saugus to mouth at Lynn Harbor, Saugus/Revere.
MA93-23	Lynn Harbor	Estuary	6.67	An imaginary line from Bass Pont, Nahany to the corporate boundary between Revere and Winthrop at Shortbeach Creek excluding the Saugus River

[1] Units = Miles for river segments and square miles for estuaries

An overview of the North Coastal watershed pathogen impairment is provided in this section to illustrate the nature and extent of the impairment. Since pathogen impairment has been previously established and documented on the *2002 List*, it is not necessary to provide detailed documentation of pathogen impairment herein. Data from the MADEP WQA, Massachusetts Division of Marine Fisheries (DMF), Saugus River Watershed Council (SRWC) and the Salem Sound Coastwatch were reviewed and are summarized by segment below for illustrative purposes.

This TMDL was based on the current WQS using fecal coliform as an indicator organism for fresh and marine waters and enterococci for marine beaches. Enterococci data are provided at the bottom of each table when data are available. The MADEP is in the process of developing new WQS incorporating *E. coli* and enterococci as indicator organisms for all waters other than shellfishing and potable water intake areas. Not all data presented herein were used to determine impairment listing due to a variety of reasons (including data quality assurance and quality control). The MADEP used only a subset of the available data to generate the *2002 List*. Other data presented in this section are for illustrative purposes only.

Data from the Massachusetts Division of Marine Fisheries (DMF) were used, in part, as the basis for pathogen impairment for many of the estuarine areas (Figure 1-1). Numerous samples have been collected throughout the North Coastal watershed by the DMF. DMF has a well-established and effective shellfish monitoring program that provides quality assured data for each shellfish growing area. In addition, each growing area must have a complete sanitary survey every 12 years, a triennial evaluation every three years and an annual review in order to maintain a shellfishing harvesting classification with the exception of those areas already classified as Prohibited. The National Shellfish Sanitation Program establishes minimum requirements for sanitary surveys, triennial evaluations, annual reviews and annual fecal coliform water quality monitoring and includes identification of specific sources and assessment of effectiveness of controls and attainment of standards. "Each year water samples are collected by the DMF at 2,320 stations in 294 growing areas in Massachusetts's coastal waters at a minimum frequency of five times while open to harvesting." (DMF 2002a) Due to the volume of data collected by the DMF, only a small sub-set of these data are provided herein. For the most recent indicator bacteria sampling data, please contact your local city or town shellfish constable or DMF's Shellfish Project.

Data summarized in the following subsections can be found at:

- **Division of Marine Fisheries. 2002.** The Marine Resources of Salem Sound, 1997. Available for download at http://www.salemsound.org/news.htm.
- **Massachusetts Department of Environmental Protection. 2000**. North Coastal Watershed 1997/1998 Water Quality Assessment Report. Available for download at: http://www.mass.gov/dep/brp/wm/wqassess.htm.
- **Saugus River Watershed Council. 2004**. Saugus River Watershed 2003 Water Quality Report. Available for download at: http://www.saugusriver.org.
- **Salem Sound Coastwatch. 2004**. Salem Sound Clean Beaches and Streams Program 2004 Report. Salem Sound Coast Watch. Available for download at: http://www.salemsound.org/clean_beaches.htm.

Data are broken down into two weather conditions: wet and dry. When data were not categorized as such in individual reports, data collected on days when there was measurable precipitation were considered wet weather conditions and data collected on days when no or "trace" amounts of precipitation were reported were considered dry weather conditions. It should be noted that some reporting entities require a minimum amount of precipitation (e.g., 0.1 or 0.2 inches) before it is considered wet weather. Therefore data between reporting entities may not be directly comparable, but overall conclusions for each segment remain consistent.

The MADPH publishes annual reports on the testing of public and semi-public beaches for both marine and fresh waters. These documents provide water quality data for each bathing beach by community and note if there were exceedances of water quality criteria. There is also a list of communities that did not report testing results. These reports can be downloaded from http://www.mass.gov/dph/beha/tox/reports/beach/beaches.htm. Marine and freshwater beach status is highly variable and is therefore not provided in each segment description. Please see the MADPH annual beach report for specific details regarding swimming beaches.

The purpose of this section of the report is to briefly describe the impaired waterbody segments in the North Coastal watershed. For more information on any of these segments, see the "*North Coastal Watershed 1997/1998 Water Quality Assessment Report*" on the MADEP website: http://www.mass.gov/dep/brp/wm/wqassess.htm

The Essex Bay System

"The western drainage area of the Essex Bay system is comprised of Castle Neck Creek, Hog Island Channel, and the Essex River, which has four tributaries. The Essex River tributaries include Soginese Creek, Lufkin Creek, Ebben Creek and Alewife Brook. Walker Creek, Lanes Creek, and Farm Creek also discharge into Essex Bay along its southeastern shore." (MADEP 2000a) The Essex Bay system drains into Ipswich Bay. Two segments of the Essex Bay system, the Essex River and Essex Bay, are impaired due to excessive indicator bacteria concentrations.

Essex River Segment MA93-11

This segment is a 0.9 mi^2 Class SA tidal estuary located from east of Southern Avenue to the mouth of Essex Bay, Essex. A four unit elderly housing complex discharges to the Essex River. The MADEP WQA lists no water withdrawals from this segment.

Shellfish growing areas status: Conditionally Approved for 0.72 mi^2; Prohibited for 0.18 mi^2 (Figure 1-1).

Essex Bay Segment MA93-16

This segment is a 1.15 mi^2 Class SA tidal estuary located in three communities, Essex, Ipswich and Gloucester. The MADEP WQA lists no discharges or withdrawals for this segment.

Shellfish growing area status: Conditionally Approved (Figure 1-1).

The Annisquam River System

"The Annisquam River system, which is also hydraulically connected to Gloucester Harbor through the Blynman Canal, includes the Jones River, Little River and the Mill River. The Mill River sub-watershed is comprised of Alewife Brook, Babson Reservoir, an unnamed tributary between Babson Reservoir and Mill Pond, and the Mill River." (MADEP 2000a) The Annisquam River system drains into Ipswich Bay. Four segments of the Annisquam River system, the Mill and Annisquam Rivers and Rockport and Gloucester Harbors, are impaired due to excessive levels of indicator bacteria.

Mill River Segment MA93-28

This segment is a 0.09 mi^2 Class SA tidal estuary. It lies between the outlet of Mill pond and the confluence of the Annisquam River in central Gloucester. The MADEP WQA lists no withdrawals and one NPDES permitted discharge. The Riverside Avenue Pumping Station Bypass for Gloucester holds a NPDES permit authorizing discharge of 0.015 million gallons per day (mgd) four times per year (MADEP 2000a).

Shellfish growing area status: Conditionally Approved (Figure 1-1).

Annisquam River Segment MA93-12

This segment is a 1.90 mi^2 Class SA tidal estuary. It starts at the confluence with the Mill River and runs to Ipswich Bay. The MADEP WQA lists no withdrawals and one NPDES permitted discharge. The City of Gloucester Pumping Station Bypass holds a NPDES permit authorizing two outfall discharges to the river (MADEP 2000a). The MADEP WQA also lists the Cape Ann Marine vessel sewage pump-out as a discharger in the segment.

Shellfish growing area status: Conditionally Approved (Figure 1-1).

Rockport Harbor Segment MA93-17

This segment is a 0.02 mi^2 Class SB estuary. It is located near downtown Rockport. The MADEP WQA defines Rockport Harbor as the waters between an imaginary line drawn between Bearskin Neck and the area called the Headlands. The MADEP WQA lists no withdrawals and two NPEDS permitted discharges. Permitted discharges of treated sanitary waste are located outside the harbor, but close enough that they may tidally affect the estuary. The MADEP WQA also lists the Rockport Harbor vessel sewage pump-out facility as a discharger to this segment (MADEP 2000a).

Shellfish growing area status: Prohibited (Figure 1-1).

Gloucester Harbor Segment MA93-18

This segment is a 2.24 mi^2 Class SB estuary located in south Gloucester. The MADEP WQA defines Gloucester Harbor as the waters between an imaginary line drawn between Dog Bar Breakwater and Mussel point. The MADEP WQA lists no withdrawals and 41 NPDES permitted discharges within Gloucester Harbor. Forty of the discharges are classified as minor discharge facilities (i.e. discharge less than 1,000,000 gallons per day) and are predominantly found in the inner Harbor. The only major facility is the water pollution control facility on the Annisquam River with the outfall located south of Dog Bar Breakwater (CZM 2004). The treatment plant discharges

outside the harbor, but the effluent may affect the estuary due to tidal influences (EOEA 2004). Four CSOs discharge to Gloucester Harbor. They are located in the North Channel, Harbor Cove, and Pavilion Beach. There are 17 storm drains which discharge an annual estimated 575,000,000 gallons of storm water to Gloucester Harbor (CZM 2004).

Shellfish growing area status: Prohibited (Figure 1-1).

The Salem Sound System

"The Salem Sound area is comprised primarily of four major drainage systems. These systems flow to either the Manchester, Beverly, Salem or Marblehead Harbors." (MADEP 2000a) The drainage system that discharges to Beverly Harbor runs through an urbanized area including sections of Salem, Peabody, Danvers, and Beverly. "Excluding the four drainage systems, Salem Sound is broadly defined as the waters inside of an imaginary line drawn from Marblehead Light northeast to the southwestern point on Bakers Island, Beverly and from the northwestern point on Bakers Island to Gales Point, Manchester. Chubb Creek is the only named stream discharging directly to Salem Sound." (MADEP 2000a) There are 21 impaired segments in the Salem Sound System.

Both the DMF and the Salem Sound Coastwatch have collected water samples in Salem Sound to analyze for potential pathogens. Rather than attempt to divide these data by watershed segments, it is presented here as two sets.

Salem Sound Coastwatch, a local watershed conservation group, collects water samples from storm water outfalls and coastal streams in Salem Sound as part of their Clean Beaches and Streams Program. The results of their 2004 sampling and bacterial analysis in Salem Sound are shown in Table 4-4. Table 4-5 presents the results from beach water sample analyses conducted by municipalities in Salem Sound.

In 1997, the Massachusetts Department of Marine Fisheries (DMF) conducted a year long study of marine resources in Salem Sound. Part of this study involved sampling fecal coliform in river, shore, and marine stations (DMF 2002b). A summary of these results are presented in Table 4-6. Sampling locations are illustrated on Figure 4-1.

Cat Brook Segment MA93-29

This segment is 2.5 mile Class B brook. It flows from the boundary of Manchester, Essex, and Gloucester, north of Route 128, southwest through Manchester and into Manchester Harbor. Cat Brook belongs to the Manchester Harbor Drainage System. Causeway and Sawmill Brooks are the two named tributaries of Cat Brook. Down stream of Sawmill Brook, Cat Brook is sometimes referred to as Sawmill Brook. The MADEP WQA lists one withdrawal and no NPDES permitted discharges to the brook (MADEP 2000a).

Table 4-4. Salem Sound Coastwatch--Water Quality Monitoring Results 2004 from Outfall Pipes and Streams in the Salem Sound Watershed (SSCW 2004). Units are cfu/100 mL. Ent = enterococci, stubble it on ns = not sampled. All samples collected at low tide.

Beach Sampled and Location	Site #	Test	Dry 6/8	Dry 6/22	Dry 7/6	Dry 7/20	Dry 8/3	Wet 8/17	Wet 8/31	Dry 9/14
Marblehead										
Stramski Beach - Stream draining across beach	722	Ent	300	700	1,400	600	1,500	1,300	6,400	1,200
Stramski Way - near pkg lot after playground	722a	Ent	<100	1400	2,100	800	2,100	1,200	7,400	1,000
Stramski Way - near field	722b	Ent	200	900	3,300	<100	<100	100	21,000	<100
Hawthorne Pond - end of street	750a	Ent	100	<100	<100	ns	ns	ns	ns	ns
Hawthorne Pond	750b	Ent	<100	<100	200	ns	ns	ns	ns	ns
Hawthorne Pond - boardwalk	750c	Ent	ns	ns	Ns	400	<100	ns	ns	ns
Beverly										
Dane St. Beach - N. storm drain	322	Ent	<100	100	500	<100	<100	100	11,900	400
Lawrence Street brook at beach	321	Ent	<100	100	200	300	<100	300	5,800	200
Rice Beach-Stream draining across beach	214	Ent	200	200	900	<100	300	400	16,000	300
Brackenberry Beach - Stream across beach	213	Ent	100	700	500	300	500	400	1,300	400
Northern storm drain at beach	213a	Ent	100	3,300	300	400	400	300	31,000	600
SW storm drain at beach	222	Ent	ns	500	900	100	600	<100	13,000	600
Danvers										
Holton-Richmond School-field	400a	Ent	ns	1,400	700	300	200	100	3,900	1,600
Bunky's Marina - Porter River	401a	Ent	ns	100	200	<100	200	<100	4,500	<100
Sandy Beach - outfall pipe	430	Ent	ns	1,600	<100	<100	100	500	44,000	<100
Sandy Beach - downstream of outfall pipe	430a	Ent	ns	ns	Ns	<100	ns	<100	1,900	200

Beach Sampled and Location	Site #	Test	Dry	Dry	Dry	Dry	Dry	Wet	Wet	Dry
			6/8	6/22	7/6	7/20	8/3	8/17	8/31	9/14
Crane River Marina	431a	Ent	ns	ns	Ns	<100	ns	ns	ns	ns
Eden Glen Road	491b	Ent	ns	100	100	200	<100	<100	ns	ns
Manchester										
Bennett's Brook - at Bennett St.	149	Ent	<100	200	1000	1,700	300	200	6,400	700
Bennett's Brook - Forster Rd.	149a	Ent	ns	ns	Ns	ns	<100	400	100	500
Raymond Street	150	Ent	ns	100	200	ns	ns	ns	500	100
Salem										
Juniper Beach - storm drain on beach	620	Ent	600	900	17,000	200	9,400	600	100,000	69,000
Juniper Beach - storm drain	620	FC	60,000	47,000	210,000	1,400	950,000	2,800	160,000	450,000
Palmer Cove - storm drain at Shetland Park	629	Ent	2,100	1,300	1,100	1,500	400	400	15,000	2,000
Palmer Cove-storm drain below Playground	631	Ent	<100	<100	<100	<100	35,000	300	20,000	800
Willow Ave. Beach - storm drain on beach	642	Ent	ns	ns	Ns	100	4,000	1,800	14,000	8,000
Collins Cove - Arbella St. stairs	527	Ent	ns	ns	Ns	400	ns	ns	6,600	ns
Willows Pier	546	Ent	ns	ns	Ns	ns	ns	ns	ns	ns
North River - off Commercial St. near Rt. 114	537	Ent	400	900	1,100	100	400	300	3,800	1,000
North River - south side, capped outfall	557	Ent	<100	<100	<100	ns	ns	ns	ns	ns
North River - off Commercial St. by footbridge	559	Ent	ns	ns	Ns	1,600	700	500	13,000	600
Derby Wharf	630	Ent	ns	400	Ns	300	<100	500	12,000	1,400
Pioneer Village	634	Ent	ns	500	Ns	ns	ns	ns	ns	ns

Table 4-5. Salem Sound Bathing Beaches Tested by Local Boards of Health, 2004 Swimming Season.

Figures listed in this table are the geometric mean of all available water quality testing results per beach by municipality (SSCW 2004). Units are cfu/100 mL

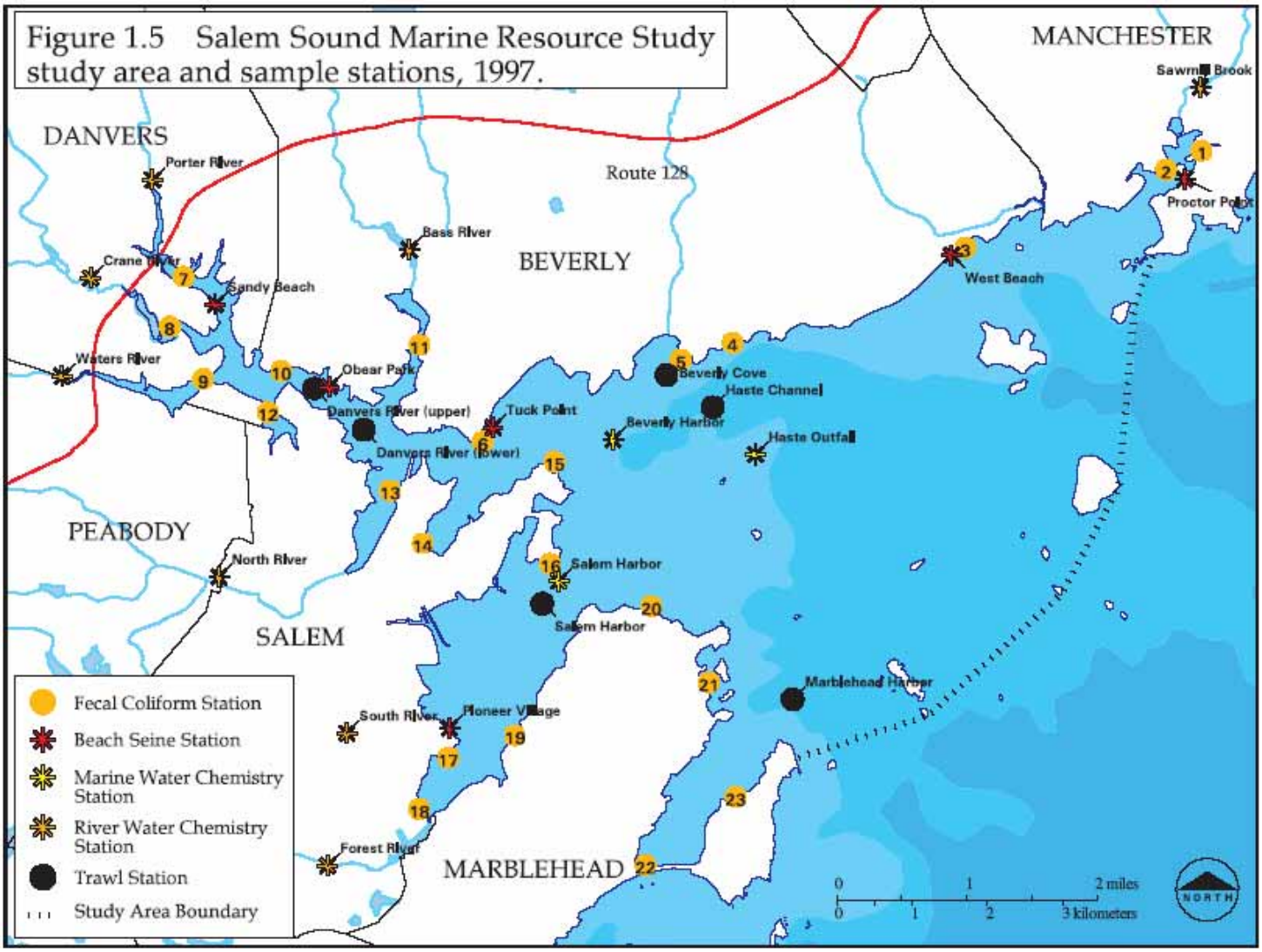
City and Beach Sampled	Enterococci (including rain events)	Range in Enterococci
Beverly		
Brackenbury Beach	9	2 – 36
Dane St. (mid-beach)	11	2 – 80
Goat Hill1	10	2 – 115
Independence Park	9	2 – 174
Lynch Park	11	2 – 146
Mingo Beach	18	2 – 95
Ober Park8	8	2 – 46
Rice Beach	5	2 – 44
Sandy Point	9	2 – 134
West Beach	14	2 – 56
Woodbury Beach	10	2 – 380
Danvers		
Sandy Beach East	32	2 – 755
Sandy Beach West	28	2 – 870
Manchester		
Black Beach	10	1 – 97
Magnolia Beach	7	1 – 97
Manchester Bath and Tennis	4	1 – 61
Singing Beach	3	1 – 22
Singing Beach (right of pkg. lot)	3	1 – 17
Tucks Point Beach	9	1 – 87
West Manchester Beach	16	1 – 190
White Beach	9	1 – 89
Marblehead		
Crocker Park	6	2 – 31
Devereaux Beach	6	2 – 460
Gas House Beach	12	2 – 220
Grace Oliver Beach	13	2 – 440
Stramski Beach	8	2 – 49
Village Beach1	19	2 – 185
Salem		
Collins Cove	8	2 – 32
Dead Horse Beach	6	2 – 80
Forest River Point	10	2 – 52
Juniper Point	9	2 – 28
Mackey Beach	7	2 – 71
Naumkeag	11	2 – 96
Ocean Ave. Beach	31	1 – 1100
Osgood Beach	6	2 – 77
Pickman Park	32	1 – 210

City and Beach Sampled	Enterococci (including rain events)	Range in Enterococci
Pioneer1	13	2 – 320
Steps Beach	4	1 – 24
Willow Ave	33	.1 – 490
Willows Pier	8	1 – 33
Winter Island	7	2 – 48

Table 4-6. Summary Statistics for Fecal Coliform Levels in River, Shore, and Marine Stations in Salem Sound, 1997 (DMF 2002b).

Station	Samples (No.)	Min. (fcc/100 ml)	Max. (fcc/100 ml)	Geo. Mean (fcc/100 ml)	> 43 (%)	> 260 (%)
SHORE						
Manchester Harbor						
Masconomo Park	20	3	1587	36	30	20
Manchester YC	20	3	110	16	25	0
Beverly Shore						
West Beach	18	3	347	19	28	11
Mingo Beach	18	3	900	38	50	17
Lynch Park	18	<3	87	9	11	0
Tuck Point	18	3	900	16	22	6
Danvers River						
Porter River	17	7	1587	67	59	12
Crane River	18	12	1587	172	94	28
Waters River	18	3	169	34	50	0
Fosters Point	18	3	347	26	22	6
Bass River	18	19	1587	96	72	17
Kernwood River	18	3	900	52	56	6
North River	18	3	900	118	83	33
Salem Shore						
Collins Cove	15	3	>2400	49	53	20
Willows Pier	18	3	>2400	31	44	11
Winter Island	18	3	110	6	6	0
Forest River Park	18	3	532	49	50	11
Forest River	18	3	347	55	61	11
Marblehead Shore						
Village Street	18	3	1587	11	22	6
Fluen Point	18	3	169	10	28	0
Browns Island	18	3	169	10	17	0
Inner Harbor	18	3	>2400	42	67	11
Eastern YC	18	3	>2400	10	17	6
RIVER						
Sawmill Brook	11	28	>2400	336	100	55
Bass River	5	4	133	15	40	0
Porter River	11	243	>2400	1149	100	91
Crane River	11	7	900	266	100	64
Waters River	11	14	>2400	446	100	73
North River	11	900	>2400	2009	100	100
South River	4	87	>2400	437	100	50
Forest River	3	7	99	21	50	0
MARINE						
Haste Outfall (plume)	3	14	347	82	66	33
Haste Outfall	9	<3	243	15	66	0
Beverly Cove	7	<3	133	4	14	0
Beverly Harbor	9	<3	4	2	0	0
Upper Danvers River	8	<3	97	7	37	0
Lower Danvers River	9	<3	61	10	33	0
Salem Harbor	9	<3	4	2	0	0
Marblehead Harbor	8	<3	>2400	8	12	12

Figure 4-1 Location of Sampling Points for DMF Study of Salem Sound Marine Resources, 1997 (DMF 2002b). Numbers used to designate sampling location.



During a 1997 and 1998 survey, MADEP collected 11 samples and DMF collected 13 samples from sites on Cat Brook below its confluence with Sawmill Brook. Fecal coliform levels in the MADEP samples ranged from < 20 to 920 cfu/100 mL (6 samples collected). Samples collected between April and October, 1997 all exceeded 400 cfu/100 mL. *E. coli* values ranged from <20 to 620 cfu/100mL. Fecal coliform levels in DMF samples collected between April and October, 1997 ranged from 133 to > 2,400 cfu/100 mL with 50% exceeding 200 cfu/100 mL (11 samples collected). On the two dry weather sampling days, fecal coliform levels exceeded 400 cfu/100 mL (MADEP 2000a).

Manchester Harbor Segment MA93-19

This segment is a 0.29 mi^2 Class SB estuary. The MADEP WQA defines the harbor as the waters inside an imaginary line drawn across the narrows at Proctor Point. MADEP WQA lists no withdrawals and no NPDES permitted discharges to this segment. The MADEP WQA lists the vessel sewage pump-out facilities at Manchester Marina and Crocker's Boat Yard, both in Manchester, as the only dischargers to the harbor.

Shellfish growing areas status: Prohibited (Figure 1-1).

Bass River Segment MA93-08

This segment is a 2.9 mile Class SB river which drains the majority of southwest Beverly. The Bass River lies in a highly urbanized portion of the Beverly Harbor drainage system with industrial practices located close to the river. The MADEP WQA lists no withdrawals and two NPDES permitted discharge to this segment. Varian Associates is authorized to discharge non-contact cooling water and storm water.

One sample was collected from the river in 1998 during wet weather. The fecal coliform count was 4,000 cfu/100 mL and *E. coli* was 1000 cfu/100mL (MADEP 2000a).

Shellfish growing areas status: Prohibited (Figure 1-1).

Frost Fish Brook Segment MA93-36

This segment is a 1.3 mile Class B river. The headwaters of Frost Fish Brook are south of Putnamville Reservoir in Danvers. The brook flows from this location to its confluence with the Porter River in Danvers at the Route 62 Bridge. The MADEP WQA lists no withdrawals from the brook and one NPDES permitted discharge, Thermadyne Wingersheek Building (MADEP 2000a).

MADEP collected water samples from two locations in Frost Fish Brook on seven separate occasions in 1997 and 1998. Fecal coliform levels in the samples ranged from <20 to 3,100 cfu/100 mL. *E. coli* counts ranged from <20 to 1,900 cfu/100mL.

Porter River Segment MA93-04

This segment is a 0.1 mi^2 Class SB estuary. This segment of the Porter River is located between the river's confluence with Frost Fish Brook and its confluence with the Danvers River. There are no withdrawals and one NPDES permitted discharge. However, this discharge was eliminated 1997 (MADEP 2000a).

During the 1997 primary contact recreation season, the DMF collected eight water samples from this segment of the Porter River. Fecal coliform levels in the samples ranged from 347 to >2,400 cfu/100 mL. Eighty percent of the samples contained over 400 cfu/100 mL, including both samples collected during dry weather conditions (MADEP 2000a).

Shellfish growing areas status: Prohibited (Figure 1-1).

Beaver Brook Segment MA93-37

This segment is a 3.5 mile Class B Brook. Beaver Brook originates west of Dayton Street in Danvers and flows to Mill Pond, also in Danvers. The MADEP WQA lists no known withdrawals or discharges (MADEP 2000a).

Water samples were collected in June, July and September 1997 from one location on Beaver Brook. Fecal coliform levels in the samples ranged from 280 to 540 cfu/100 mL. Two samples were analyzed for *E. coli* (July and September). *E. coli* values were 280 and 340 for July and September 1997 respectively.

Crane Brook Segment MA93-02

This segment is a 2.3 mile Class B, warm water fishery. Crane Brook flows from its headwaters west of the Newburyport Turnpike in Danvers to Mill Pond, also in Danvers. The MADEP WQA lists no known withdrawals and two NPDES permitted discharges (MADEP 2000a). GTE Sylvania has two authorized non-contact cooling water discharges within this segment.

MADEP sampled for fecal coliform and *E. coli* bacteria in Crane Brook at two locations in 1997 and 1998. Fecal coliform levels at one station ranged from 100 to 900 cfu/100 mL (3 samples) with the elevated level occurring during dry weather conditions. *E. coli* ranged from 20 to 120 at this station (3 samples). Fecal coliform levels at the second station ranged from 80 to 280 cfu/100 mL (3 samples) and *E. coli* counts were 60 and 80 cfu/100mL (2 samples; MADEP 2000a).

Crane River Segment MA93-38

This segment is a 0.3 mile Class B waterbody. This segment of the Crane River flows from the outlet of Mill Pond to the sluiceway at Purchase Street in Danvers. The MADEP WQA lists no known withdrawals and one NPDES permitted discharge, Riverside Condominiums (MADEP 2000a).

The MADEP sampled the Crane River for fecal coliform and *E. coli* in 1997 and 1998. Fecal coliform counts ranged from 80 to 2,400 cfu/100mL and *E. coli* ranged from <20 to 400 cfu/100mL (6 samples). Only one sample exceeded 400 cfu/100mL (MADEP 2000a).

The DMF collected fecal coliform samples on 11 occasions in 1997. Values ranged from 110 to 900 cfu/100mL during the primary contact recreation season. The results of the two dry weather samples were 243 and 532 cfu/100mL (MADEP 2000a)

Crane River Segment MA93-41

This segment is a 0.08 mi^2 Class SA waterbody. This segment of the Crane River runs from the pump house sluiceway on purchase Street in Danvers to its confluence with the Danvers River. The MADEP WQA lists no known withdrawals and one NPDES permitted discharge, Crane River West Condominiums storm water discharge (MADEP 2000a).

Shellfish growing areas status: Prohibited (Figure 1-1).

Waters River Segment MA93-01

This segment is a 0.08 mi^2 Class SB tidal estuary. The Waters River flows from its headwaters near the Peabody/Danvers line upstream of Mount Pleasant drive in Peabody to its confluence with Danvers River in Danvers. The MADEP WQA lists no known withdrawals and two possible NPDES permitted discharges (MADEP 2000a). One permit was issued to a facility which is now closed; the other permit has expired with no reapplication on file.

The MADEP sampled the Waters River for fecal coliform and *E. coli* on six occasions between 1997 and 1998. Fecal coliform counts ranged from 200 to 3,200 cfu/100mL and *E. coli* ranged from 20 to 1,200 cfu/100mL (MADEP 2000a).

The DMF collected fecal coliform samples on 11 occasions in 1997. Sixty-three percent of the samples exceeded 400 cfu/100mL. Values ranged from 347 to 900 cfu/100mL (MADEP 2000a).

Shellfish growing areas status: Prohibited (Figure 1-1).

Goldthwait Brook Segment MA93-05

This segment is a 3.3 mile Class B, Warm Water Fishery. Goldthwait Brook flows from Cedar Pond to its confluence with Proctor Brook in the center of Peabody. Goldthwaite Brook flows through Craig's Pond and is joined by Tapley Brook near the Eastman Gelatin Corp. facility. The MADEP WQA list two permitted withdrawals and three NPDES permitted discharges. One withdrawal is from Spring Pond which is in the Tapley Brook sub-watershed. The second withdrawal is from Sydney's Pond (MADEP 2000a). NPDES permits include non-contact cooling water and storm water discharges from Eastman Gelatine Corporation, filter backwash from the Coolidge Avenue Water Treatment Facility and a discharge permit from the Stahl Finishing hazardous waste site (MADEP 2000a).

The MADEP collected fecal coliform and *E. coli* bacteria samples on two occasions from Goldthwait Brook in 1997 and 1998. Fecal coliform counts were <20 and 40 cfu/100mL. *E. coli* counts were both <20 cfu/100m (MADEP 2000a).

Proctor Brook Segment MA93-39

This segment of Proctor Brook is a 2.9 mile Class B waterbody. This segment begins in a wetland just north of Downing Road in Peabody and ends at the Goodhue Street Bridge. The MADEP WQA lists two withdrawals (the Peabody Water Department and the Salem Country Club) and four NPDES permitted discharges (MADEP 2000a). The NPDES permits include an overflow discharge from the Peabody Municipal Light Plant cooling pond, process equipment cooling water from Salem Oil & Grease, non-contact cooling water from Bayoil Co. and a 21E discharge from Federal Express (MADEP 2000a).

The MADEP sampled Proctor Brook for fecal coliform and *E. coli* on six occasions between 1997 and 1998. Fecal coliform counts ranged from 640 to 41,000 cfu/100mL and *E. coli* ranged from 200 to 4,500 cfu/100mL (MADEP 2000a).

The DMF collected fecal coliform samples on 11 occasions in 1997. All samples collected were greater than 900 cfu/100mL. Dry weather values were >2,400 cfu/100mL (MADEP 2000a).

Proctor Brook Segment MA93-40

This segment of Proctor Brook is a 0.01 mi^2 Class SB waterbody. The segment flows between Goodhue St. and the Route 114 Bridge/culvert in Salem. Proctor Brook then discharges to the North River Estuary. The MADEP WQA lists no withdrawals nor discharges (MADEP 2000a).

Shellfish growing areas status: Prohibited (Figure 1-1).

North River Segment MA93-42

The North River estuary is a 0.20 mi^2 Class SA waterbody. This estuary lies between the Route 114 bridge/culvert in Peabody and its confluence with the Danvers River. The MADEP WQA lists no known withdrawals nor discharges (MADEP 2000a).

Shellfish growing areas status: Prohibited (Figure 1-1).

Danvers River Segment MA93-09

This segment is a 0.50 mi^2 Class SB estuary. The Danvers River estuary is formed at the confluence of the Porter, Crane and Waters Rivers near Davenport. The estuary discharges into Beverly Harbor. The Bass River and the North River also flow into the Danvers River upstream of its confluence with Beverley Harbor. The MADEP WQA lists one registered withdrawal, the Kearnwood Country Club. The vessel sewage pump-out facilities at the Danvers yacht club in Danvers is the only listed discharge (MADEP 2000a).

Shellfish growing areas status: Prohibited (Figure 1-1).

Beverly Harbor Segment MA93-20

This segment is a 0.78 mi^2 Class SB waterbody. Beverly Harbor is located east of the Bridge Street Bridge between Beverly/Salem to an imaginary line between Woodbury Point in Beverly southwest to Salem Neck in Salem. The MADEP WQA lists one NPDES permitted discharge, a former CSO

discharge, and a discharge from the vessel sewage pump-out facilities at the Ferryway Public Landing in Beverly. No withdrawals are listed (MADEP 2000a).

Shellfish growing areas status: Prohibited (Figure 1-1).

Forest River Segment MA93-10

This segment is a 0.05 mi^2 Class SB waterbody. The Forest River flows from approximately one half mile upstream of Loring Avenue, Salem and discharge into Salem Harbor, Salem/Marblehead. MADEP WQA lists no known withdrawals or discharges (MADEP 2000a).

The MADEP sampled Forest River for fecal coliform and *E. coli* on two occasions, June 1997 and March 1998. Fecal coliform counts were 540 and 20 cfu/100m for June and March respectively. *E. coli* values were 280 and <20 cfu/100mL (MADEP 2000a).

The DMF collected fecal coliform samples on three occasions in 1997. All samples collected were below 200 cfu/100mL. Dry weather values were >2,400 cfu/100mL (MADEP 2000a).

Although the DMF Shellfish Status Report of January 1999 does not specifically designate this segment as a growing area, shellfishing would be prohibited due to excessive heavy metal concentrations (MADEP 2000a).

Salem Harbor Segment MA93-21

Salem Harbor is a 1.62 mi^2 Class SB estuary. The MADEP WQA defines the harbor as the waters inside of an imaginary line drawn across Winter Island, Salem to Naugus Head, Marblehead. MADEP WQA lists several NPDES permitted outfalls into the Harbor and a discharge from the vessel sewage pump-out facilities at Winter Island talk, Salem. No withdrawals are listed (MADEP 2000a). The NPDES discharges from the USGenNE facility includes:

- Outfall 001: discharging condenser cooling water, boiler blowdown, reboiler and evaporator blowdown, freshwater storage tank overflow, service water, boiler blowdown tanks, and storm water
- Outfall 006: discharging wastewater treatment service ash settling point, seal water, floor & equipment drains, blowdown and storm water
- Outfall 005 and 007: discharging intake screen wash water
- Outfall 15: discharging emergency spillway overflow

Shellfish growing areas status: Prohibited (Figure 1-1).

Marblehead Harbor Segment MA93-22

This segment is a 0.56 mi^2 Class SA estuary. The MADEP WQA defines the harbor as the waters inside of an imaginary line drawn from Fort Sewell to Marblehead Light. MADEP WQA lists no known withdrawals and one discharge from the vessel sewage pump-out facilities at the Cliff St. boat yard in Marblehead (MADEP 2000a).

Shellfish growing areas status: Prohibited (Figure 1-1).

Salem Sound Segment MA93-25

This segment is a 10.01 mi^2 Class SB waterbody. The MADEP WQA defines Salem Sound as the waters inside of an imaginary line drawn from Marblehead Light northeast to the southwestern point on Bakers Island, Beverly, and then from the northwest point on Bakers Island to Gales Point, Manchester. This segment excludes Marblehead, Salem, Beverly and Manchester harbors as they are defined as separate segments. The MADEP WQA lists two NPDES permitted discharges from wastewater treatment plants (WWTP) and no known withdrawals (MADEP 2000a). The WWTP include the South Essex Sewer District and the Manchester By-The-Sea WWTP.

Shellfish growing areas status: Prohibited (Figure 1-1).

Nahant Bay Segment MA93-24

Nahant Bay is a 5.27 mi^2 Class SA estuary. The MADEP WQA defines Nahant Bay as the waters inside of an imaginary line drawn across Galloupes or Phillips Point, Swampscott, to East Point, Nahant. The MADEP WQA lists no withdrawals and two NPDES permitted discharges into Nahant Bay (MADEP 2000a). The NPDES discharges include the Lynn Water and Sewer Commission, a wet weather combined sewer overflow (CSO), and the Swampscott WWTP.

Shellfish growing areas status: Prohibited (Figure 1-1).

Saugus River System

The Saugus River system originates at the outlet of Lake Quannapowitt in Wakefield and eventually flows into the estuary downstream of the Saugus River Ironworks in Saugus. The River receives flow from four tributaries in its freshwater reach including Beaverdam Brook, Mill River, Hawks Brook and Bennett's Pond Brook. Shutes Brook discharges into the tidal Saugus River, which is joined by the Pines River. They flow into Lynn Harbor, which eventually discharges into Broad Sound.

The Saugus River Watershed Council collected samples from various places along the Saugus River for analysis of *E. coli* bacteria in 2003. Results from their 2003 sampling effort are shown in Table 4-7 and Figure 4-2 (SRWC 2004). A map of sampling locations is provided in Figure 4-3.

Saugus River Segment MA93-34

This segment is a 3.1 mile Class B Treated Water Supply. This segment of the Saugus River runs from the outlet of Lake Quannapowitt in Wakefield to a small impoundment where water is withdrawn to supply public water to the city of Lynn. MADEP WQA lists two withdrawals and one NPDES permitted discharge (non-contact cooling water from Power Products, Inc) to this segment of the Saugus River (MADEP 2000a).

The MADEP collected two fecal coliform samples from this segment of the Saugus River in the summer of 1997, and one *E. coli* sample. Fecal coliform counts were 40 and 160 cfu/100mL. The single *E. coli* count was <20 cfu/100mL.

Table 4-7. Saugus River Watershed Council 2003 Water Quality Monitoring Data (SRWC 2004)

2003 *E. coli*						
		June	July	August	October	Geometric
		6/30/03	7/29/03	8/27/03	10/23/03	Mean
Site #						
SR 2	River @ L. Quannapowitt	127	38	2,000	45	146.43
SR 3	Dam @ Colonial	35	13	46	8	26.43
SR 4	Breakheart Bridge	77	129	89	23	86.12
SR 6	Route 1	126	100	137	27	104.59
SR 7	Prankers Pond	350	95	198	35	146.81
SR 8	Iron Works	183	130	282	66	162.51
SR10	Boston St.	2,000	2,000	110	39	509.46
SRT2	Mill River	72	72	170	21	91.15
SRT3	Mill R. @ Town Br.	111	255	2,000	165	293.21
SRT4	Shute Brook	276	2,000	109	238	368.42
SRT6	Strawberry Br.	0	36	2,000	60	185.48
SRT8	Pt. Of Pines	45	3	178	29	25.67
SRT9	Trifone Brook (TLB)	2,000	2,000	2,000	0	2,000.00
SRT10	Town Line Br./Rte.1	63	44	60	33	56.18
SRT11	Town Line Br./Cemetery	2,000	2,000	271	2,000	857.62
SRT12	Flax Pond	222	58	44	62	64.59

U.S. USEPA water quality criteria for swimming is 236 E. Coli/100 mL
U.S. USEPA water quality criteria for boating is 576 E. Coli/100 mL
A geometric mean of 126 E. Coli or lower meets the U.S. USEPA water quality criteria for swimming.

Figure 4-2. Saugus River Watershed Council 2003 *E. coli* Results (SRWC 2004).

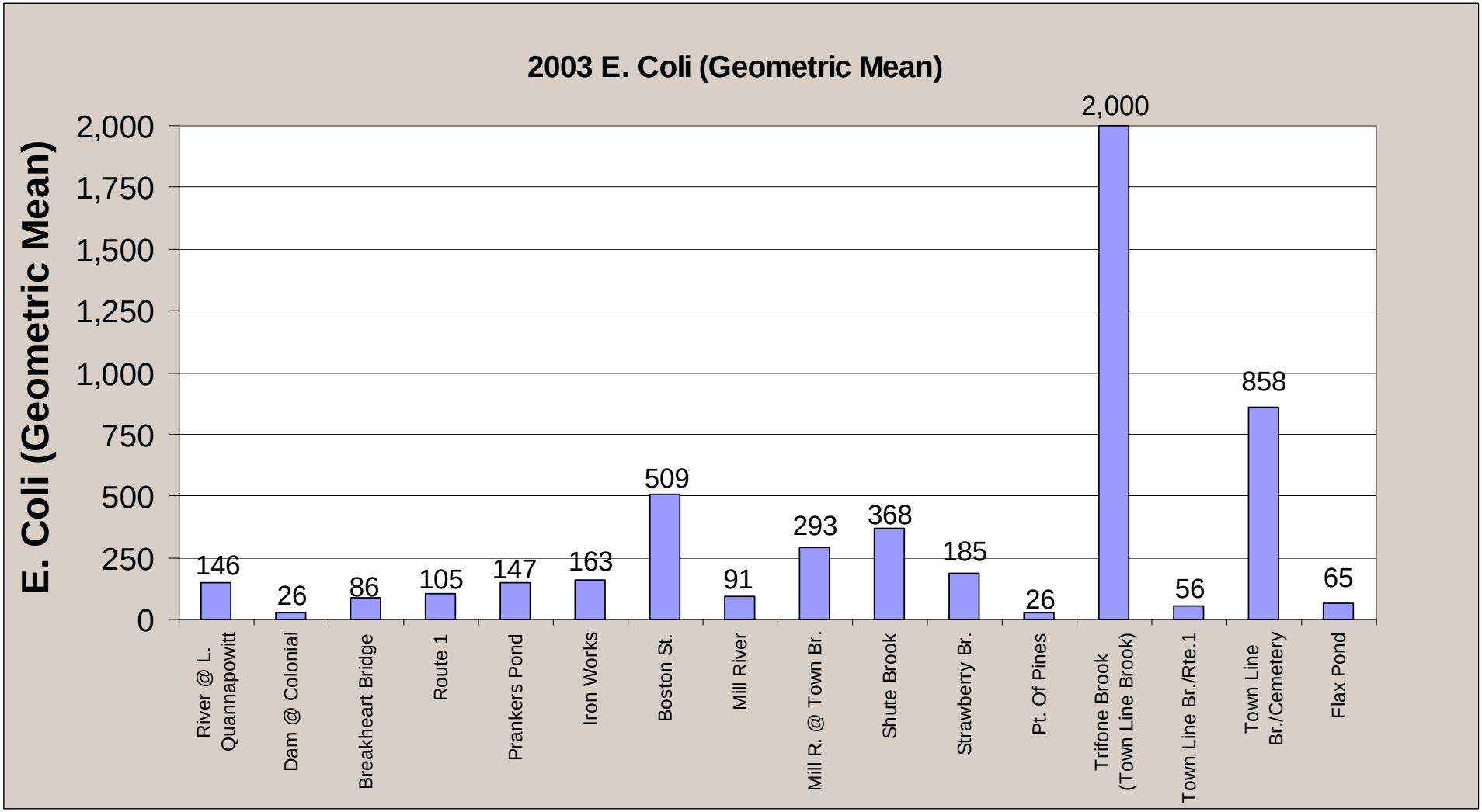
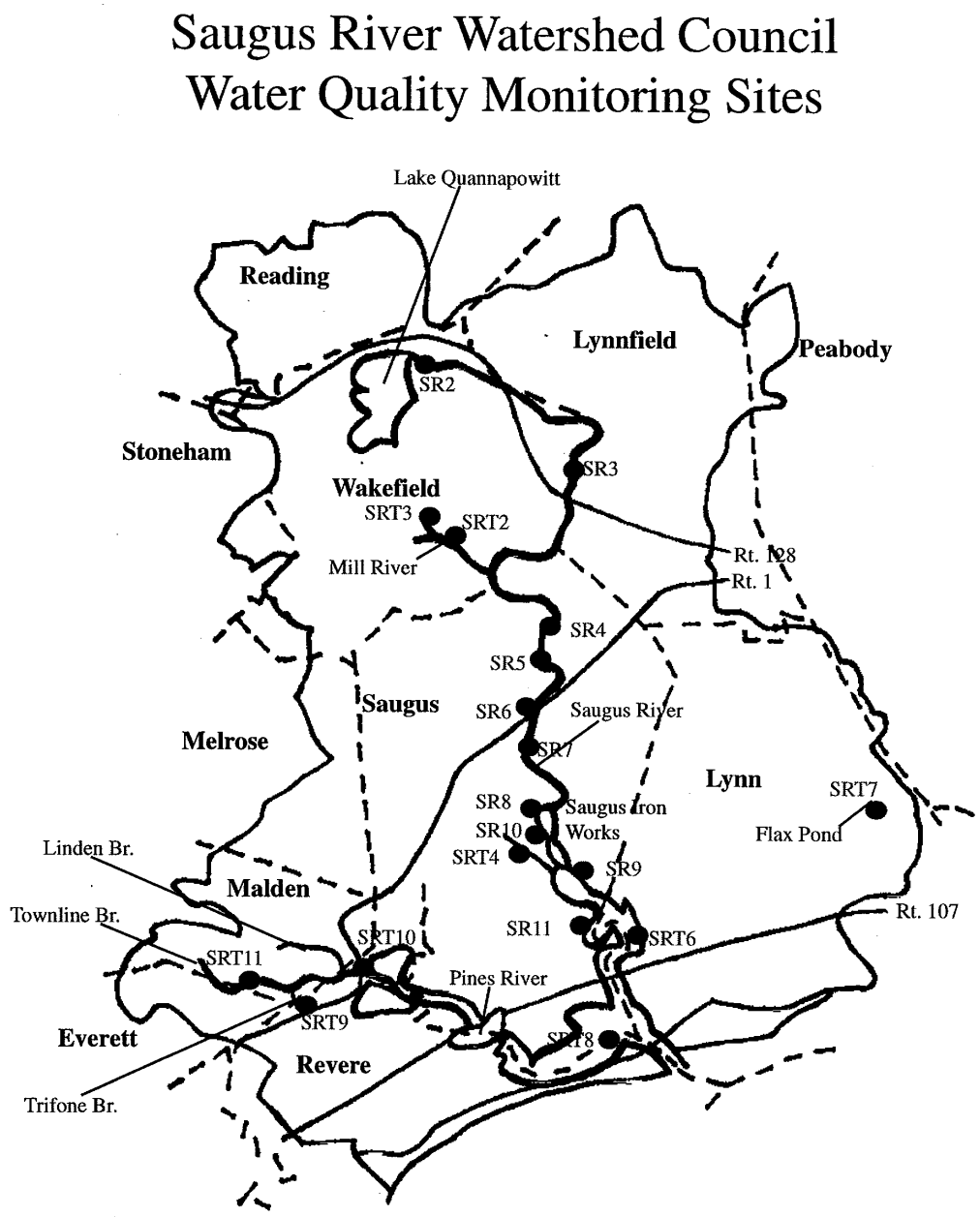


Figure 4-3. Saugus River Watershed Council Water Quality Monitoring Sites



SR2 - Lake Quannapowitt Outflow, Wakefield
SR3 - Dam at Sheraton Colonial, Wakefield
SR4 - River at Water Street, Wakefield
SR5 - Breakheart/Camp Nihan Bridge, Saugus
SR6 - Route 1 @ Dunkin Donuts, Saugus
SR7 - Prankers Pond, Saugus
SR8 - Saugus Iron Works, Saugus
SR9 - Old Railroad Bridge/Hamilton Street, Saugus
SR10 - Boston Street Bridge, Lynn
SR11 - Ballard Street, Saugus

SRT2 - Mill River @ Farm & Water Street, Wakefield
SRT3 - Mill River @ Town Brook
SRT4 - Shute Brook @ Winter Street Cemetery, Saugus
SRT6 - Strawberry Brook @ Summer Street, Lynn
SRT7 - Flax Pond, Lynn
SRT8 - Point of Pines, Revere
SRT9 - Trifone Brook, Revere
SRT10 - Town Line Brook @ Route 1, Revere
SRT11 - Town Line Brook @ Cemeteries, Malden

Beaverdam Brook Segment MA93-30

This segment is a 2.5 mile Class B waterbody. Beaver Dam Brook originates just east of Main Street in Lynnfield and flows into the Saugus River just north of the Wakefield/Lynnfield town line. MADEP WQA lists one withdrawal and one NPDES permitted discharge, both for the Lynnfield Center Water District (MADEP 2000a).

The MADEP collected a total of seven fecal coliform and five *E. coli* samples from two locations on this segment of Beaverdam Brook in 1997 and 1998. Fecal coliform values ranged from <20 to 2,000 cfu/100mL. Two fecal coliform samples collected during dry weather contained 1,600 and 2,000 cfu/100 mL. The other five samples contained between <20 and 400 cfu/100 mL (MADEP 2000a). *E. coli* ranged from <20 to 800 cfu/100mL.

Saugus River Segment MA 93-35

This segment of the Saugus River is listed in the MADEP WQA as a 5.3 mile Class SB waterbody. One of the MADEP WQA recommendations is, however, that this segment be described as a Class B, Warm Water Fishery since this segment is not tidally influenced. The MADEP WQA states that this segment begins in wetlands in Reading and Wakefield, but recommendations that the segment begins at the canal which discharges into Hawkes Pond. The segment does extend to Saugus Iron Works. MADEP WQA lists no withdrawals or discharges (MADEP 2000a).

The MADEP collected 19 fecal coliform samples at three locations on the Saugus River in 1997 and 1998, including two samples from a piped discharge along this segment. A total of 13 *E. coli* samples were also collected. Fecal coliform values ranged from <20 to 2,450 cfu/100mL. *E. coli* values ranged from <20 to 1,250 cfu/100mL (MADEP 2000a).

Mill River Segment MA93-31

The Mill River is a 2.0 mile Class B waterbody. The River originates just south of Salem Street in Wakefield and flows to its confluence with the Saugus River also in Wakefield. The MADEP WQA lists one withdrawal, Wakefield Water Department, and four NPDES permitted discharges (MADEP 2000a). NPDES dischargers include the Wakefield Corporation, Wakefield Bearing Corp., Spirit Inc., and the Crystal Lake Water Treatment Plant.

Three Mill River stations were sampled for fecal coliform and *E. coli* by the MADEP in 1997. Two piped discharges were also sampled once during 1997. Fecal coliform in the river samples ranged from 40 to 600 cfu/100mL (8 samples), and 1,300 to 1,500 cfu/100ml for the two piped discharges. *E. coli* values ranged from 20 to 600 cfu/100mL in the river samples. The two pipe samples were 320 and 480 cfu/100mL.

Hawkes Brook Segment MA93-32

This segment of Hawkes Brook is a 2.6 mile Class A, Outstanding Resource Water. It originates on the southwestern side of Bow Ridge at the municipal border between Lynn and Lynnfield and discharges into Hawkes Pond. The MADEP WQA lists one withdrawal (Lynn Water and Sewer Commission) and no discharges to this segment of Hawkes Brook (MADEP 2000a).

The MADEP collected fecal coliform and *E. coli* samples from one location in this segment of Hawkes Brook during 1997. Fecal coliform levels ranged between 460 to 2000 cfu/100 mL (4 samples). Three samples collected during dry weather conditions all contained more than 400 cfu/100 mL (MADEP 2000a). *E. coli* samples ranged from 120 to 700 cfu/100mL (3 samples).

Hawkes Brook Segment MA93-33

This segment of Hawks Brook is a 1.1 mile Class B waterbody. It flows from the outlet of Hawkes Pond to its confluence with the Saugus River. The MADEP WQA lists no withdrawals or discharges (MADEP 2000a).

In 1997, MADEP collected water samples for bacterial analysis six times from one location for fecal coliform and four times for *E. coli*. Fecal coliform levels ranged from <20 to 2,400 cfu/100 mL. Three samples collected during dry weather conditions all contained more than 400 cfu/100 mL (MADEP 2000a). *E. coli* samples ranged from <20 to 1,000 cfu/100mL.

Saugus River Segment MA93-14

This segment is a 0.80 mi^2 Class SB estuary. This segment of the Saugus River starts just downstream of the Saugus Iron Works National Historic Site and eventually flows into Lynn Harbor. From Boston Street to the mouth of the estuary, this segment is designated as an Outstanding Resource Water because it is part of the Rumney Marshes Areas of Critical Environmental Concern. The MADEP WQA lists one withdrawal (Carr Leather Company) and four NPDES permitted dischargers to this segment of the Saugus River (MADEP 2000a). The Lynn Water and Sewer Commission has authorization for a wet weather CSO discharge. The other three dischargers include Refuse Energy Systems Company, General Electric Company, and Eastern Tool and Stamping. Discharges from these three companies include non-contact cooling water, contact cooling water, stream condensate, floor drainage, boiler blowdown, boiler filter backwash, ion exchange regeneration and backwash, flash tank blowdown, oil coolers, cooling tower blowdown, engine test cells wash waters and storm water.

The MADEP found greater than 2,000,000 cfu/100 mL fecal coliform in water collected at the Summer St/Strawberry Brook outfall. The Saugus River Watershed Council reported frequent excessive bacterial counts at this outfall in both wet and dry conditions (MADEP 2000a).

Shellfish growing areas status: Prohibited (Figure 1-1).

Pines River Segment MA93-15

This segment is a 0.70 mi^2 Class SB estuary and is also designated an Outstanding Resource Water because it is included in the Rumney Marshes Areas of Critical Environmental Concern. The segment runs from the Route 1 bridge in Revere/Saugus to the mouth of the Saugus River. The MADEP WQA lists no withdrawals and four NPDES permitted discharges (MADEP 2000a). NPDES dischargers include the Refuse Energy Systems Company, GLEN-MOR Fuel Oil Co., Holiday Fitness Center, and Sports Oil Co.

Shellfish growing areas status: Prohibited (Figure 1-1).

Lynn Harbor Segment MA93-23

This segment is a 6.67 mi^2 Class SB estuary. The MADEP WQA defines this segment as the waters inside an imaginary line drawn across Bass Point, Nahant, to the corporate boundary between Revere and Winthrop at Shortbeach Creek. The MADEP WQA lists five outfalls from the Lynn Water and Sewer Commission discharging to Lynn Harbor; although, one my actually discharge to Broad Sound (MADEP 2000a). Three of these discharges are wet weather CSO outfalls.

MADEP collected water samples for fecal coliform analysis from two CSOs under dry (October 1997) and wet weather conditions (August 1998). Dry weather sample results ranged from 14,000 and > 10,000,000 cfu/100 mL. Wet weather sample results were 94,000 and 110,000 cfu/100 mL.

Shellfish growing areas status: Prohibited (Figure 1-1).

5.0 Potential Sources

The North Coastal watershed has 36 segments, located throughout the watershed, that are listed as pathogen impaired requiring a TMDL. These segments represent 100% of the estuary area and 87.7% of the river miles assessed. Sources of indicator bacteria in the North Coastal watershed are many and varied. A significant amount of work has been done in the last decade to improve the water quality in the North Coastal watershed.

Largely through the efforts of the MADEP, DMF, local governments, and the volunteers of numerous local conservation groups such as Salem Sound Coastwatch and the Saugus River Watershed Council, numerous point and non-point sources of indicator bacteria have been identified. Table 5-1 summarizes the river segments impaired due to measured indicator bacteria densities and identifies some of the suspected and known sources identified in the WQA or by other organizations.

Some dry weather sources include:

- leaking sewer pipes,
- storm water drainage systems (illicit connections of sanitary sewers to storm drains),
- failing septic systems,
- recreational activities,
- wildlife including birds, and
- illicit boat discharges.

Some wet weather sources include:

- wildlife and domesticated animals (including pets),
- storm water runoff including municipal separate storm sewer systems (MS4),
- combined sewer overflows (CSOs), and
- sanitary sewer overflows (SSOs).

It is difficult to provide accurate quantitative estimates of indicator bacteria contributions from the various sources in the North Coastal watershed because many of the sources are diffuse and intermittent, and extremely difficult to monitor or accurately model. Therefore, a general level of quantification according to source category is provided (e.g., see Tables 5-2 and 5-3). This approach is suitable for the TMDL analysis because it indicates the magnitude of the sources and illustrates the need for controlling them. Additionally, many of the sources (failing septic systems, leaking sewer pipes, sanitary sewer overflows, and illicit sanitary sewer connections) are prohibited, because they indicate a potential health risk and, therefore, must be eliminated. However, estimating the magnitude of overall indicator bacteria loading (the sum of all contributing sources) is achieved for wet and dry conditions using the extensive ambient data available that define baseline conditions (see segment summary tables and MADEP 2000a).

Table 5-1. Some of the Potential Sources of Bacteria in Pathogen Impaired Segments in the North Coastal Watershed.

Segment	Potential Sources
Essex River MA93-11	Failing septic systems, storm drains
Essex Bay MA93-16	Failing septic systems, storm drains
Mill River MA93-28	Failing septic systems, Riverside Avenue Pumping Station Bypass, storm drains
Annisquam River MA93-12	Failing septic systems, Gloucester Pumping Station Bypass, storm drains, tributaries
Rockport Harbor MA93-17	Rockport WWTP and Cape Ann lighthouse treated sanitary waste discharges, failing septic systems
Gloucester Harbor MA93-18	Failing septic systems, City of Gloucester WWTP, CSOs, sewage pumping station bypasses, storm drains, and marine sediments
Cat Brook MA93-29	Illegal sewer connections
Manchester Harbor MA93-19	Surface waters discharging to the harbor
Bass River MA93-08	CSO (eliminated in 1997)
Frost Fish Brook MA93-36	Unknown
Porter River MA93-04	CSO (eliminated in 1997)
Beaver Brook MA93-37	Unknown
Crane Brook MA93-02	Unknown
Crane River MA93-41	Unknown
Crane River MA93-38	Unknown
Waters River MA93-01	Unknown
Goldthwait Brook MA93-05	Unknown
Proctor Brook MA93-39	Unknown
Proctor Brook MA93-40	Upstream fecal coliform levels
North River MA93-42	Upstream fecal coliform levels
Danvers River MA-93-09	CSOs
Beverly Harbor MA93-20	Surface waters discharging to the harbor
Forest River MA93-10	Unknown
Salem Harbor MA93-21	Surface waters discharging to the harbor
Marblehead Harbor MA93-22	Unknown
Salem Sound MA93-25	WWTPs
Nahant Bay MA93-24	CSOs, untreated sewage from an underdrain

Segment	Potential Sources
Saugus River MA93-34	Unknown
Beaverdam Brook MA93-30	WWTP
Saugus River MA93-35	Tributaries
Mill River MA93-31	Two discharge pipes (source unspecified)
Hawkes Brook MA93-32	Unknown
Hawkes Brook MA93-33	CSO
Saugus River MA93-14	CSO, WWTP, tributaries
Pines River MA93-15	Unknown
Lynn Harbor MA93-23	CSO

Potential sources obtained from MADEP 2000 and CZM 200

Sanitary Waste

Leaking sewer pipes, illicit sewer connections, sanitary sewer overflows (SSOs), combined sewer overflows (CSOs) and failing septic systems represent a direct threat to public health since they result in discharge of partially treated or untreated human wastes to the surrounding environment. Quantifying these sources is extremely speculative without direct monitoring of the source because the magnitude is directly proportional to the volume of the source and its proximity to the surface water. Typical values of fecal coliform in untreated domestic wastewater range from 10^4 to 10^6 MPN/100mL (Metcalf and Eddy 1991).

Illicit sewer connections into storm drains result in direct discharges of sewage via the storm drainage system outfalls. The existence of illicit sewer connections to storm drains is well documented in many urban drainage systems, particularly older systems that may have once been combined. The EPA, MWRA, the Boston Water and Sewer Commission (BWSC) and many communities throughout the Commonwealth have been active in the identification and mitigation of these sources. It is estimated by EPA New England that over one million gallons per day (gpd) of illicit discharges were removed in the last decade in the Charles River Watershed, for example. It is probable that numerous illicit sewer connections exist in storm drainage systems serving the older developed portions of the North Coastal watershed.

Monitoring of storm drain outfalls during dry weather is needed to document the presence or absence of sewage in the drainage systems. Approximately 80.0% of the North Coastal watershed is classified as Urban Areas by the United States Census Bureau and is therefore subject to the Stormwater Phase II Final Rule that requires the development and implementation of an illicit discharge detection and elimination plan. See Section 7.0 of this TMDL for information regarding illicit discharge detection guidance.

Septic systems designed, installed, operated and maintained in accordance with 310 CMR 15.000: Title 5, are not significant sources of fecal coliform bacteria. Studies demonstrate that wastewater located four feet below properly functioning septic systems contain on average less than one fecal

coliform bacteria organism per 100 mL (Ayres Associates 1993). Failed or non-conforming septic systems, however, can be a major contributor of fecal coliform to the North Coastal watershed. Wastes from failing septic systems enter surface waters either as direct overland flow or via groundwater. Wet weather events typically increase the rate of transport of pollutant loadings from failing septic systems to surface waters because of the wash-off effect from runoff and the increased rate of groundwater recharge.

Recreational use of waterbodies is a source of pathogen contamination. Swimmers themselves may contribute to bacterial impairment at swimming areas. When swimmers enter the water, residual fecal matter may be washed from the body and contaminate the water with pathogens. In addition, small children in diapers may contribute to contamination of the recreational waters. These sources are likely to be particularly important when the number of swimmers is high and the flushing action of waves or tides is low.

Another potential source of pathogens is the discharge of sewage from vessels with onboard toilets. These vessels are required to have a marine sanitation device (MSD) to either store or treat sewage. When MSDs are operated or maintained incorrectly they have the potential to discharge untreated or inadequately treated sewage. For example, some MSDs are simply tanks designed to hold sewage until it can be pumped out at a shore-based pump-out facility or discharged into the water more than 3 miles from shore. Uneducated boaters may discharge untreated sewage from these devices into near-shore waters. In addition, when MSDs designed to treat sewage are improperly maintained or operated they may malfunction and discharge inadequately treated sewage. Finally, even properly operating MSDs may discharge sewage in concentrations higher than allowed in ambient water for fishing or shellfishing. Vessels are most likely to contribute to bacterial impairment in situations where large numbers of vessels congregate in enclosed environments with low tidal flushing. Many marinas and popular anchorages are located in such environments.

Wildlife and Pet Waste

Animals that are not pets can be a potential source of pathogens. Geese, gulls, and ducks are speculated to be a major pathogen source, particularly at lakes and storm water ponds where large resident populations have become established (Center for Watershed Protection 1999).

Household pets such as cats and dogs can be a substantial source of bacteria – as much as 23,000,000 colonies/gram, according to the Center for Watershed Protection (1999). A rule of thumb estimate for the number of dogs is ~1 dog per 10 people producing an estimated 0.5 pound of feces per dog per day. Based on an estimated population in the North Coastal watershed of 500,000 people (EOEA 2003), this translates into 25,000 lbs/day of animal feces. Uncollected pet waste is then flushed from the parks, beaches and yards where pets are walked and transported into nearby waterways during wet-weather.

Storm Water

Storm water runoff is another significant contributor of pathogen pollution. As discussed above, during rain events fecal matter from domestic animals and wildlife are readily transported to surface waters via the storm water drainage systems and/or overland flow. The natural filtering capacity provided by vegetative cover and soils is dramatically reduced as urbanization occurs because of the increase in impervious areas (i.e., streets, parking lots, etc.) and stream channelization in the watershed.

Extensive storm water data have been collected and compiled both locally and nationally (e.g., Tables 4-1, 4-2, 5-2 and 5-3) in an attempt to characterize the quality of storm water. Bacteria are easily the most variable of storm water pollutants, with concentrations often varying by factors of 10 to 100 during a single storm. Considering this variability, storm water bacteria concentrations are difficult to accurately predict. Caution must be exercised when using values from single wet weather grab samples to estimate the magnitude of bacteria loading because it is often unknown whether the sample is representative of the "true" mean. To gain an understanding of the magnitude of bacterial loading from storm water and avoid overestimating or underestimating bacteria loading, event mean concentrations (EMC) are often used. An EMC is the concentration of a flow proportioned sample throughout a storm event. These samples are commonly collected using an automated sampler which can proportion sample aliquots based on flow. Typical storm water event mean densities for various indicator bacteria in Massachusetts watersheds and nationwide are provided in Tables 5-2 and 5-3. These EMCs illustrate that storm water indicator bacteria concentrations from certain land uses (i.e., residential) are typically at levels sufficient to cause water quality problems.

Table 5-2. Lower Charles River Basin Storm Water Event Mean Bacteria Concentrations (data summarized from USGS 2002) and Necessary Reductions to Meet Class B WQS.

Land Use Category	Fecal Coliform EMC (CFU/100 mL)	Number of Events	Class B WQS[1]	Reduction to Meet WQS (%)
Single Family Residential	2,800 – 94,000	8	10% of the samples shall not exceed 400 organisms/ 100 mL	2,400 – 93,600 (85.7 – 99.6)
Multifamily Residential	2,200 – 31,000	8		1,800 – 30,600 (81.8 – 98.8)
Commercial	680 – 28,000	8		280 – 27,600 (41.2 – 98.6)

[1] Class B Standard: Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms. Used 400 to illustrate required reductions since a geometric mean of the samples were not provided.

Table 5-3. Storm Water Event Mean Fecal Coliform Concentrations (as reported in MADEP 2002; original data provided in Metcalf & Eddy, 1992) and Necessary Reductions to Meet Class B WQS.

Land Use Category	Fecal Coliform[1] Organisms / 100 mL	Class B WQS[2]	Reduction to Meet WQS (%)
Single Family Residential	37,000	10% of the samples shall not exceed 400 organisms/ 100 mL	36,600 (98.9)
Multifamily Residential	17,000		16,600 (97.6)
Commercial	16,000		15,600 (97.5)
Industrial	14,000		13,600 (97.1)

[1] Derived from NURP study event mean concentrations and nationwide pollutant buildup data (USEPA 1983).

[2] Class B Standard: Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms. Used 400 to illustrate required reductions since a geometric mean of the samples were not provided.

6.0 Pathogen TMDL Development

Section 303 (d) of the Federal Clean Water Act (CWA) requires states to place water bodies that do not meet the water quality standards on a list of impaired waterbodies. The most recent impairment list, *2002 List*, identifies 36 segments within the North Coastal watershed for use impairment caused by excessive indicator bacteria concentrations.

The CWA requires each state to establish Total Maximum Daily Loads (TMDLs) for listed waters and the pollutant contributing to the impairment(s). TMDLs determine the amount of a pollutant that a waterbody can safely assimilate without violating the water quality standards. Both point and non-point pollution sources are accounted for in a TMDL analysis. Point sources of pollution (those discharges from discrete pipes or conveyances) subject to NPDES permits receive a waste load allocation (WLA) specifying the amount of pollutant each point source can release to the waterbody. Non-point sources of pollution (all sources of pollution other than point) receive a load allocation (LA) specifying the amount of a pollutant that can be released to the waterbody by this source. In accordance with the CWA, a TMDL must account for seasonal variations and a margin of safety, which accounts for any lack of knowledge concerning the relationship between effluent limitations and water quality. Thus:

$$TMDL = WLAs + LAs + Margin\ of\ Safety$$

Where:

WLA = Waste Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future point source of pollution.

LA = Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future non-point source of pollution.

This TMDL uses an alternative standards-based approach which is based on indicator bacteria concentrations, but considers the terms of the above equation. This approach is more in line with the way bacterial pollution is regulated (i.e., according to concentration standards) and achieves essentially the same result as if the equation were to be used.

6.1. Indicator Bacteria TMDL

Loading Capacity

The pollutant loading that a waterbody can safely assimilate is expressed as either mass-per-time, toxicity or some other appropriate measure (40 CFR § 130.2). Typically, TMDLs are expressed as total maximum daily loads. Expressing the TMDL in terms of daily loads is difficult to interpret given the very high numbers of indicator bacteria and the magnitude of the allowable load is dependent on flow conditions and, therefore, will vary as flow rates change. For example, a very high load of indicator bacteria are allowable if the volume of water that transports indicator bacteria is also high. Conversely, a relatively low load of indicator bacteria may exceed water quality standard if flow rates are low. Therefore, the MADEP believes it is appropriate to express indicator bacteria TMDLs in

terms of a concentration because the WQS is also expressed in terms of the concentration of organisms per 100 mL. Since source concentrations may not be directly added due to varying flow conditions, the TMDL equation is modified and reflects a margin of safety in the case of this pathogen concentration based TMDL. To ensure attainment with Massachusetts' WQS for indicator bacteria, all sources (at their point of discharge to the receiving water) must be equal to or less than the WQS for indicator organisms. For all the above reasons the TMDL is simply set equal to the concentration-based standard and may be expressed as follows:

$$TMDL = State\ Standard = WLA_{(p1)} = LA_{(n1)} = WLA_{(p2)} = etc.$$

Where:

$WLA_{(p1)}$ = allowable concentration for point source category (1)
$LA_{(n1)}$ = allowable concentration for nonpoint source category (1)
$WLA_{(p2)}$ = allowable concentration for point source category (2) etc.

For Class A surface waters (1) *the arithmetic mean of a representative set of fecal coliform samples shall not exceed 20 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 100 organisms per 100 mL.*

For Class B and Class SB and SA areas not designated for shellfishing (1) *the geometric mean of a representative set of fecal coliform samples shall not exceed 200 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 400 organisms per 100 mL*.

For Class SA open shellfish area surface waters (1) *the geometric mean of a representative set of fecal coliform samples shall not exceed 14 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 43 organisms per 100 mL.*

For Class SB open shellfish surface waters (1) *the geometric mean of a representative set of fecal coliform samples shall not exceed 88 organisms per 100 mL*; and (2) *no more than 10% of the samples shall exceed 260 organisms per 100 mL.*

For marine bathing beaches (BEACH Act standard) (1) *the geometric mean of a statistically sufficient number of samples (generally not less than 5 samples equally spaced over a 30-day period) shall not exceed 35 colonies per 100 mL* and (2) *no single enterococci sample shall exceed 104 colonies per 100 mL*.

For freshwater bathing beaches (MADPH standard, not yet adopted by the MADEP) (1) *the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 33 colonies per 100 mL* and (2) *no single enterococci sample shall exceed 61 colonies per 100 mL*. – OR – (1) *the geometric mean of the most recent five E. coli levels within the same bathing season shall not exceed 126 colonies per 100 mL* and (2) *no single E. coli sample shall exceed 235 colonies per 100 mL.*

Waste Load Allocations (WLAs) and Load Allocations (LAs).

There are several WWTPs and other NPDES-permitted wastewater discharges within the North Coastal watershed. NPDES wastewater discharge WLAs are set at the WQS. In addition there are numerous storm water discharges from storm drainage systems throughout the watershed. All piped discharges are, by definition, point sources regardless of whether they are currently subject to the requirements of NPDES permits. Therefore, a WLA set equal to the WQS will be assigned to the portion of the storm water that discharges to surface waters via storm drains.

WLAs and LAs are identified for all known source categories including both dry and wet weather sources for Class SA, Class SB, Class A and B segments within the North Coastal watershed. Establishing WLAs and LAs that only address dry weather indicator bacteria sources would not ensure attainment of standards because of the significant contribution of wet weather indicator bacteria sources to WQS exceedances. Illicit sewer connections and deteriorating sewers leaking to storm drainage systems represent the primary dry weather point sources of indicator bacteria, while failing septic systems and possibly leaking sewer lines represent the non-point sources. Wet weather point sources include discharges from storm water drainage systems (including MS4s), sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs). Wet weather non-point sources primarily include diffuse storm water runoff.

Table 6-1 presents the indicator bacteria WLAs and LAs for the various source categories. WLAs and LAs will change to reflect the revised indicator organisms (*E. coli* and enterococci) when the updated WQS have been finalized (See Section 3.0 of this report). Source categories representing discharges of untreated sanitary sewage to receiving waters are prohibited, and therefore, assigned WLAs and LAs equal to zero. There are several sets of WLAs and LAs, one for Class SA shellfish open waters, one for Class SB shellfish open waters, one for Class A waters, one for Class B and shellfish restricted Class SA and SB waters, one for no discharge areas, one for freshwater beaches, and one for marine beaches.

The TMDL should provide a discussion of the magnitudes of the pollutant reductions needed to attain the goals of the TMDL. Since accurate estimates of existing sources are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For the illicit sources including failing septic systems, the goal is complete elimination (100% reduction). However, overall wet weather indicator bacteria load reductions can be estimated using typical storm water bacteria concentrations, as presented in the "*North Coastal Watershed 1997/1998 Water Quality Assessment Report*". These data indicate that up to two to three orders of magnitude (i.e., greater than 90%) reductions in storm water fecal coliform loadings generally will be necessary, especially in developed areas. This goal is expected to be accomplished through implementation of the best management practices (BMPs) associated with the Phase II control program in designated Urban Areas. The specific goal for controlling discharges from combined sewer overflows (CSOs) will be based on the site specific studies embodied in the Long Term Control Plan being developed by each community with combined sewers.

Table 6-1. Indicator Bacteria Waste Load Allocations (WLAs) and Load Allocations (LAs) for the North Coastal Watershed.

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
A, B, SA, SB	Illicit discharges to storm drains	0	N/A
A, B, SA, SB	Leaking sanitary sewer lines	0	N/A
A, B, SA, SB	Failing septic systems	N/A	0
A	NPDES – WWTP	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples nor shall 10% of the samples exceed 100 organisms[2]	N/A
A	Storm water runoff Phase I and II	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples nor shall 10% of the samples exceed 100 organisms[3]	N/A
A	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples nor shall 10% of the samples exceed 100 organisms[3]
B & Not Designated for Shellfishing SA & SB	CSOs	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[4]	N/A
B & Not Designated for Shellfishing SA & SB	NPDES – WWTP	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[2]	N/A
B & Not Designated for Shellfishing SA & SB	Storm water runoff Phase I and II	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[3]	N/A
B & Not Designated for Shellfishing SA & SB	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms[3]

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
SA Designated Shellfishing Areas	NPDES – WWTP	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms[2]	N/A
SA Designated Shellfishing Areas	Storm water Runoff Phase I and II	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms[3]	N/A
SA Designated Shellfishing Areas	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 14 organisms in any set of representative samples, nor shall 10% of the samples exceed 43 organisms[3]
SB Designated Shellfishing Areas	CSOs	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[4]	N/A
SB Designated Shellfishing Areas	NPDES – WWTP	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[2]	N/A
SB Designated Shellfishing Areas	Storm water runoff Phase I and II	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[3]	N/A
SB Designated Shellfishing Areas	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 88 organisms in any set of representative samples, nor shall 10% of the samples exceed 260 organisms[3]
No Discharge Areas	Vessels – raw or treated sanitary waste	0	N/A
Marine Beaches[5]	All Sources	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies	Enterococci not to exceed a geometric mean of 35 colonies in a statistically significant number of samples, nor shall any single sample exceed 104 colonies

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)[1]	Load Allocation Indicator Bacteria (CFU/100 mL)[1]
Fresh Water Beaches[6]	All Sources	Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies OR *E. coli* not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies	Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies OR *E. coli* not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies

N/A means not applicable

[1] Waste Load Allocation (WLA) and Load Allocation (LA) refer to fecal coliform densities unless specified in table.

[2] Or shall be consistent with the Waste Water Treatment Plant (WWTP) National Pollutant Discharge Elimination System (NPDES) permit.

[3]The expectation for WLAs and LAs for storm water discharges is that they will be achieved through the implementation of BMPs and other controls.

[4] Or shall be consistent with an approved Long Term Control Plan (LTCP) for Combined Sewer Overflow (CSO) abatement. If the level of control specified in the LTCP is less than what is necessary to attain Class B water quality standards, then the above criteria apply unless MADEP has proposed and EPA has approved water quality standards revisions for the receiving water.

[5] Federal Beaches Environmental Assessment and Coastal Health Act of 2000 (BEACH Act) Water Quality Criteria

[6] Massachusetts Department of Public Health regulations (105 CMR Section 445)

Note: this table represents waste load and load reductions based on water quality standards current as of the publication date of these TMDLs, any future changes made to the Massachusetts water quality standards will become the governing water quality standards for these TMDLs.

The expectation to attain WQS at the point of discharge is environmentally protective, and offers a practical means to identify and evaluate the effectiveness of control measures. In addition, this approach establishes clear objectives that can be easily understood by the public and individuals responsible for monitoring activities.

This TMDL applies to the 36 pathogen impaired segments of the North Coastal watershed that are currently listed on the CWA § 303(d) list of impaired waters. MADEP recommends however, that the information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing "pollution prevention TMDLs" consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This North Coastal watershed TMDL may, in appropriate circumstances, also apply to segments that are listed for pathogen impairment in subsequent Massachusetts CWA § 303(d) Integrated List of Waters. For such segments, this TMDL may apply if, after listing the waters for pathogen impairment and taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

6.2. Margin of Safety

This section addresses the incorporation of a Margin of Safety (MOS) in the TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can either be implicit (i.e., incorporated into the TMDL analysis through conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings). This TMDL uses an implicit MOS, through inclusion of two conservative assumptions. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Realistically, influent water will mix with the receiving water and become diluted below the water quality standard, provided that the receiving water concentration does not exceed the TMDL concentration. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling of indicator bacteria that are known to occur.

6.3. Seasonal Variability

In addition to a Margin of Safety, TMDLs must also account for seasonal variability. Pathogen sources to North Coastal watershed waters arise from a mixture of continuous and wet-weather driven sources, and there may be no single critical condition that is protective for all other conditions. This TMDL has set WLAs and LAs for all known and suspected source categories equal to the Massachusetts WQS independent of seasonal and climatic conditions. This will ensure the attainment of water quality standards regardless of seasonal and climatic conditions. Controls that

are necessary will be in place throughout the year, protecting water quality at all times. However, for discharges that do not affect shellfish beds, intakes for water supplies and primary contact recreation is not taking place (i.e., during the winter months) seasonal disinfection is permitted for NPDES point source discharges.

7.0 Implementation Plan

Setting and achieving TMDLs must be an iterative process, with realistic goals over a reasonable timeframe and adjusted as warranted based on ongoing monitoring. The concentrations set out in the TMDL represent reductions that will require substantial time and financial commitment to be attained. A comprehensive control strategy is needed to address the numerous and diverse sources of pathogens in the North Coastal watershed.

Controls on several types of pathogen sources will be required as part of the comprehensive control strategy. Many of the sources in the North Coastal watershed including sewer connections to drainage systems, leaking sewer pipes, sanitary sewer overflows, and failing septic systems, are prohibited and must be eliminated. Individual sources must be first identified in the field before they can be abated. Pinpointing sources typically requires extensive monitoring of the receiving waters, and tributary storm water drainage systems during both dry and wet weather conditions. A comprehensive program is needed to ensure illicit sources are identified and that appropriate actions will be taken to eliminate them. The MADEP, Saugus River Watershed Council (SRWC), Salem Sound Coastwatch (SSCW), DMF, EPA and communities within the North Coastal watershed have been successful in carrying out such monitoring, identifying sources, and in some cases, mobilizing the responsible municipality and other entities to begin to take corrective actions.

Storm water runoff represents another major source of pathogens in the North Coastal watershed, and the current level of control is inadequate for standards to be attained. Improving storm water runoff quality is essential for restoring water quality and recreational uses. At a minimum, intensive application of non-structural BMPs is needed throughout the watershed to reduce pathogen loadings as well as loadings of other storm water pollutants (e.g., nutrients and sediments) contributing to use impairment in the North Coastal watershed. Depending on the degree of success of the non-structural storm water BMP program, structural controls may become necessary.

For these reasons, a basin-wide implementation strategy is recommended. The strategy includes a mandatory program for implementing storm water BMPs and eliminating illicit sources. The "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" was developed to support implementation of pathogen TMDLs. TMDL implementation-related tasks are shown in Table 7-1. The MADEP working with EPA and other team partners shall make every reasonable effort to assure implementation of this TMDL. These stakeholders can provide valuable assistance in defining hot spots and sources of pathogen contamination as well as the implementation of mitigation or preventative measures.

Table 7-1. Tasks

Task	Organization
Writing TMDL	MADEP
TMDL public meeting	MADEP
Response to public comment	MADEP
Organization, contacts with volunteer groups	MADEP/Local watershed conservation groups
Development of comprehensive storm water management programs including identification and implementation of BMPs	North Coastal Watershed Communities
Illicit discharge detection and elimination	North Coastal Watershed Communities and local watershed conservation groups
Leaking sewer pipes and sanitary sewer overflows	North Coastal Watershed Communities
CSO management	North Coastal Watershed Communities
Inspection and upgrade of on-site sewage disposal systems as needed	Homeowners, North Coastal Watershed Communities (Boards of Health)
Organize implementation; work with stakeholders and local officials to identify remedial measures and potential funding sources	MADEP, North Coastal Watershed Communities, and local watershed conservation groups
Organize and implement education and outreach program	North Coastal Watershed Communities
Write grant and loan funding proposals	MADEP, North Coastal Watershed Communities, and local watershed conservation groups
Inclusion of TMDL recommendations in Executive Office of Environmental Affairs (EOEA) Watershed Action Plan	EOEA
Surface Water Monitoring	MADEP, North Coastal Watershed Communities, and local watershed conservation groups
Provide periodic status reports on implementation of remedial activities	MADEP, North Coastal Watershed Communities, and local watershed conservation groups

7.1. Summary of Activities within the North Coastal Watershed

The North Coastal Watersheds Team has prepared a Five-Year Action Plan (Action Plan) to "serve as the strategic environmental planning document for the North Coastal Watersheds (NCW) Team for calendar years 2004-2008. It is intended to provide a long-term vision for the watershed and to describe a set of overall goals and objectives. … The Action Plan was developed in conjunction with representatives of a wide array of public watershed interests, via input at public meetings, on a website (www.NorthCoastal.net), through newspaper articles, and through videotaping at public events." (EOEA 2004). The implementation strategy of this pathogen TMDL is consistent with the Action Plan. "The goals of the NCW [North Coastal Watershed] team and the Action Plan are:

1. **Open Space:** Foster Sustainable Development (people-oriented).
2. **Habitat:** Conserve habitat and wildlife (nature-oriented).
3. **Water Quality:** Improve water quality and water-related human health.
4. **Water Quantity:** Better water management / flood control.
5. **Recreation:** Foster recreational use of natural resources and economic growth related to recreation.
6. **Outreach:** Local capacity building, outreach, and education." (EOEA 2004)

Implementation of measures to meet North Coastal watershed TMDL targets will proceed at the local level. "Formerly, EOEA's Massachusetts Watershed Initiative would have overseen the implementation of the Action Plan. With the dissolution of that Initiative, implementation will be accomplished in a more decentralized manner – primarily via local watershed groups, with some oversight and input from EOEA and other Watershed Team representatives." (EOEA 2004). This approach is particularly appropriate for the North Coastal watershed as it consists not of a single river basin, but of many drainage sub-basins, each with their own particular conditions and problems. The MADEP will work with local governments, the North Coastal watersheds Team plus local watershed and conservation organizations (such as Friends of Lynn Woods, Salem Sound Coastwatch, Saugus River Watershed Council, Eight Towns and the Bay, Chebacco Lake Association, Friends of lake Quannapowitt, Wenham Lake Watershed Association, Massachusetts Audubon Society North Shore Chapter), MWRA, USEPA, CZM – North Shore Regional Office and other team partners to make every reasonable effort to assure implementation of this TMDL

Please see the Action Plan available for download from the worldwide web at http://www.mass.gov/envir/water/publications.htm for more details on specific proposals and accomplishments to date.

Data supporting this TMDL indicate that indicator bacteria enter the North Coastal watershed from a number of contributing sources, under a variety of conditions. Activities that are currently ongoing and/or planned to ensure that the TMDL can be implemented include and are summarized in the following subsections. The "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" provides additional details on the implementation of pathogen control measures summarized below as well as additional measures not provided herein, such as by-law, ordinances and public outreach and education.

7.2. Study and Rehabilitation of Closed Coastal Shellfish Beds

Shellfish beds along most of the North Coastal watershed coast have been closed, but clamming on the beaches was once an integral part of those communities. While not confined to the North Coastal watershed, the Massachusetts Bays Comprehensive Conservation & Management Plan (MBP 2003) lists the following initiatives intended to protect and enhance shellfishing and the progress of these initiatives:

- Conducted three Sanitary Survey Training Sessions annually-one each on the North Shore, Metro Boston/South Shore, and Cape Cod-to educate local shellfish constables and health officers on the proper technique for identifying and evaluating pathogen inputs into shellfish harvesting areas (progress: full). Local partner: Division of Marine Fisheries

- Developed and administer a local Shellfish Management Grants Program to help communities finance the development and implementation of affective local shellfish management plans (progress: substantial). Local partner: Division of Marine Fisheries

- Continue and expand the Shellfish Bed Restoration Program to restore and protect shellfish beds impacted by non-point source pollution (progress: moderate). Local partner: Shellfish Bed Restoration Program

- Through the Shellfish Clean Water Initiative, complete an Interagency Agreement defining agency roles and contributions to protect shellfish resources from pollution sources (progress: new). Local partner: Office of Coastal Zone Management.

7.3. Illicit Sewer Connections, Failing Infrastructure and CSOs

Elimination of illicit sewer connections, repairing failing infrastructure and controlling impacts associated with CSOs are of extreme importance. Several municipalities have already implemented programs, have programs in place, or are planning programs to eliminate sewage discharge from CSOs and/or illicit septic system connection to storm water drains. For example:

- Lynn is under a Consent Judgment to eliminate all CSOs and to address wastewater contaminated storm water (EOEA 2004).

- Essex has entered into Consent Judgment to address the discharge of pollutants from the town's storm drainage facilities into Essex Coastal Waters. A source of these pollutants has been identified as failing septic systems that are directly or indirectly tied into the storm drainage system (EOEA 2004).

- Peabody has conducted a comprehensive inventory of the City’s existing storm water facilities. As a result of this effort, three residential septic systems were disconnected from the storm sewer. Peabody is committed to repairing sewer/storm drain cross-connections as they are discovered (Peabody 2002).

Implementation of the Storm Water Phase II Final Rule requires that municipalities detect and eliminate sewage discharges to storm sewer systems including illicit sewer connections (USEPA 2000). Implementation of this rule will thus help communities achieve bacteria TMDLs. In 2001, the North Coastal Watersheds Team contracted with an engineering consultant to conduct a series of workshops and provide technical assistance to 15 watershed municipalities for their implementation of NPDES Storm Water Phase II compliance. MADEP Phase II coordinators have been provided with all of the materials developed and presented by engineering consultant in their series of workshops on Technical Assistance for NPDES Stormwater Phase II Compliance. “These materials and follow up assistance should allow DEP to better serve the North Coastal watershed communities with timely and up to date assistance consistent with their needs and progress towards meeting Phase II compliance." (EOEA 2004)

Guidance for illicit discharge detection and elimination has been developed by EPA New England (USEPA 2004c) for the Lower Charles River. The guidance document provides a plan, available to all Commonwealth communities, to identify and eliminate illicit discharges (both dry and wet weather) to their separate storm sewer systems. Although originally prepared for the Charles River watershed it is applicable to all watersheds throughout the Commonwealth. Implementation of the protocol outlined in the guidance document satisfies the Illicit Discharge Detection and Elimination requirement of the NPDES program. A copy of the guidance document is provided in Appendix A.

7.4. Storm Water Runoff

Storm water runoff can be categorized in two forms 1) point source discharges and 2) non-point source discharges (includes sheet flow or direct runoff). Many point source storm water discharges are regulated under the NPDES Phase I and Phase II permitting programs when discharged to a Waters of the United States. Municipalities that operate regulated municipal separate storm sewer systems (MS4s) must develop and implement a storm water management plan (SWMP) which must employ, and set measurable goals for the following six minimum control measures:

1. public education and outreach particularly on the proper disposal of pet waste,
2. public participation/involvement,
3. illicit discharge detection and elimination,
4. construction site runoff control,
5. post construction runoff control, and
6. pollution prevention/good housekeeping.

Portions of towns in this watershed are classified as Urban Areas by the United States Census Bureau and are subject to the Stormwater Phase II Final Rule. This rule requires the development and implementation of an illicit discharge detection and elimination plan.

The NPDES permit does not, however, establish numeric effluent limitations for storm water discharges. Maximum extent practicable (MEP) is the statutory standard that establishes the level of pollutant reductions that regulated municipalities must achieve. The MEP standard is a narrative effluent limitation that is satisfied through implementation of SWMPs and achievement of measurable goals.

Non-point source discharges are generally characterized as sheetflow runoff and are not categorically regulated under the NPDES program and can be difficult to manage. However, some of the same principles for mitigating point source impacts may be applicable. Individual municipalities not regulated under the Phase I or II should implement the exact same six minimum control measures minimizing storm water contamination. In addition, the North Coastal Watersheds Fiver-Year Action Plan lists the following recommendations to decrease the occurrence of storm water acting as a non-point source of pathogens (EOEA 2004):

- Address pet waste as a water quality issue. People are generally unaware of the connection between pet waste and water quality as well. A brochure on this subject can be found at http://www.mass.gov/dep/brp/wm/files/petwaste.pdf

- Reduce public geese feeding, especially along lakes where both geese and people congregate. Goose waste is a major source of bacterial runoff.

- Provide technical and funding assistance for the implementation of municipal storm water plans and ensure that consent judgments are completed in a timely manner. Efforts should be prioritized within the four targeted watersheds of the Saugus River, Salem Sound, Gloucester Harbor, and Smallpox Brook.

- Encourage communities and watershed groups to take advantage of the U.S. Department of Agriculture's Natural Resources Conservation Service interest in working with communities to identify sources of storm water contamination, and evaluate remedial options. They can meet with communities to determine goals and problems, conduct watershed site visits, help them set priorities, carry out demonstration projects, and help prepare applications for funding through various grant programs (EOEA 2004).

- Educate communities to consider permit and development strategies that address storm water runoff – implementing BMPs that reduce runoff, beneficial storm water recharge, buffer zones, and Low Impact Development (LID) in general.

7.5. Failing Septic Systems

Septic system bacteria contributions to the North Coastal watershed may be reduced in the future through septic system maintenance and/or replacement. Additionally, the implementation of Title 5, which requires inspection of private sewage disposal systems before property ownership may be transferred, building expansions, or changes in use of properties, will aid in the discovery of poorly operating or failing systems. Because systems which fail must be repaired or upgraded, it is expected that the bacteria load from septic systems will be significantly reduced in the future. Regulatory and educational materials for septic system installation, maintenance and alternative technologies are provided by the MADEP on the worldwide web at http://www.mass.gov/dep/brp/wwm/t5pubs.htm. In addition, the North Coastal Watersheds Five-Year Action Plan recommends innovative use of the State Revolving Fund for septic improvement and publicizing the income tax credit for septic improvement to increase its use (EOEA 2004).

Individual municipalities have also taken steps to eliminate failing on-site septic systems as a source of pathogens to the watershed. In 2001, the town of Rockport received a Determination of Insignificance from the Massachusetts Water Resources Commission for the interbasin transfer of wastewater from the Long Beach section of Rockport to the city of Gloucester's wastewater treatment system. This transfer would eliminate a long-standing pollution problem attributed to poor individual subsurface disposal facilities. Gloucester has aggressively worked to manage its on-site septic systems. City sewers have been installed in West Gloucester to replace on-site septic systems and a plan developed to identify areas for further sewering (EOEA 2004).

7.6. Wastewater Treatment Plants

WWTP discharges are regulated under the NPDES program when the effluent is released to surface waters. Each WWTP has an effluent limit included in its NPDES or groundwater permit. Some NPDES permits are listed on the following website: www.epa.gov/region1/npdes/permits_listing_ma.html. Groundwater permits are available at http://www.mass.gov/dep/brp/gw/gwhome.htm.

Information presented in MADEP's *North Coastal Watershed 1997/1998 Water Quality Assessment Report* and the *North Coastal Watersheds Five-Year Action Plan* indicate that considerable progress has been made in eliminating wastewater treatment plant discharges as a source of human pathogens to the watershed. The *North Coastal Watersheds Five-Year Action Plan* also recommends to:

- Develop and implement a plan to provide technical and financial support to municipalities to improve compliance with all wastewater regulations, permits, consent orders, etc.
- Develop and implement a plan to provide technical support to help insure that all POTWs required to have a Local Limits program have one with a robust set of limits that address all water quality issues in their receiving waters and an enforcement program that insures compliance with all applicable limits (EOEA 2004).

7.7. Recreational Waters Use Management

Recreational waters receive pathogen inputs from swimmers and boats. To reduce swimmers' contribution to pathogen impairment, shower facilities can be made available, and bathers should be encouraged to shower prior to swimming. In addition, parents should check and change young children's diapers when they are dirty. Options for controlling pathogen contamination from boats include:

- petitioning the State for the designation of a No Discharge Area (NDA),
- supporting installation of pump-out facilities for boat sewage,
- educating boat owners on the proper operation and maintenance of marine sanitation devices (MSDs), and
- encouraging marina owners to provide clean and safe onshore restrooms and pump-out facilities.

There are currently no areas proximal to the North Coastal watershed established as “no discharge area” (NDA). NDAs are designated by the Commonwealth of Massachusetts and approved by the EPA to provide protection by Federal Law prohibiting the release of raw or treated sewage from vessels into navigable waters of the U.S. The law is enforced by the Massachusetts Environmental Police. The MACZM and Massachusetts Environmental Law Enforcement are actively pursuing an amendment to State regulations allowing for the institution of fines up to $2000 for violations within a NDA (USEPA 2004a).

7.8. Funding/Community Resources

A complete list of funding sources for implementation of non-point source pollution is provided in Section VII of the Massachusetts Nonpoint Source Management Plan Volume I (MADEP 2000b) available on line at http://www.mass.gov/dep/brp/wm/nonpoint.htm. This list includes specific programs available for non-point source management and resources available for communities to manage local growth and development. The State Revolving Fund (SRF) provides low interest loans to communities for certain capital costs associated with building or improving wastewater treatment facilities. In addition, many communities in Massachusetts sponsor low cost loans through the SRF for homeowners to repair or upgrade failing septic systems.

7.9. Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts

For a more complete discussion on ways to mitigate pathogen water pollution, see the “*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*” accompanying this document.

8.0 Monitoring Plan

The long term monitoring plan for the North Coastal watershed includes several components:

1. continue with the current monitoring of the North Coastal watershed (local watershed conservation organizations, local governments, DFM),
2. continue with MADEP watershed five-year cycle monitoring,
3. monitor areas within the watershed where data are lacking or absent to determine if the waterbody meets the use criteria,
4. monitor areas where BMPs and other control strategies have been implemented, or discharges have been removed to assess the effectiveness of the modification or elimination,
5. assemble data collected by each monitoring entity to formulate a concise report where the basin is assessed as a whole and an evaluation of BMPs can be made, and
6. add/remove/modify BMPs as needed based on monitoring results.

The monitoring plan is an ever changing document that requires flexibility to add, change or delete sampling locations, sampling frequency, methods and analysis. At the minimum, all monitoring should be conducted with a focus on:

- capturing water quality conditions under varied weather conditions,
- establishing sampling locations in an effort to pin-point sources,
- researching new and proven technologies for separating human from animal bacteria sources, and
- assessing efficacy of BMPs.

9.0 Reasonable Assurances

Reasonable assurances that the TMDL will be implemented include both enforcement of current regulations, availability of financial incentives including low or no-interest loans to communities for wastewater treatment facilities through the State Revolving Fund (SRF), and the various local, state and federal programs for pollution control. Storm water NPDES permit coverage will address discharges from municipal owned storm water drainage systems. Enforcement of regulations controlling non-point discharges includes local enforcement of the states Wetlands Protection Act and Rivers Protection Act; Title 5 regulations for septic systems and various local regulations including zoning regulations. Financial incentives include Federal monies available under the CWA Section 319 NPS program and the CWA Section 604 and 104b programs, which are provided as part of the Performance Partnership Agreement between MADEP and the EPA. Additional financial incentives include state income tax credits for Title 5 upgrades, and low interest loans for Title 5 septic system upgrades through municipalities participating in this portion of the state revolving fund program.

10.0 Public Participation

To be added later….

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Appendix A

Lower Charles River Illicit Discharge Detection & Elimination (IDDE) Protocol
Guidance for Consideration - November 2004